FCAS VERIFICATION TOOL USER GUIDE

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VERSION:	3
EFFECTIVE DATE:	1 July 2020
STATUS:	FINAL

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VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
1.0	8 February 2012	Created initial release
2.0	30 July 2017	Added description of verification tool process
3.0	1 July 2020	Updated following review of MASS focusing on interaction with Mandatory Primary Frequency Reponse rule change.

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1. INTRODUCTION

1.1. Purpose and scope

The FCAS Verification Tool (FCASVT) is an Excel spreadsheet that has been made available to NEM Participants to calculate frequency control ancillary services (FCAS) delivered by their plant offering such services to the National Electricity Market (NEM). The FCASVT will calculate Fast Raise (R6), Slow Raise (R60), Delayed Raise (R5), Fast Lower (L6), Slow Lower (L60) and Delayed Lower (L5) delivered in accordance with the Market Ancillary Services Specification (MASS). The FCASVT also permits the user to inspect in detail how the input data is processed in order to arrive at a result.

This document provides an overview of the FCASVT and a description on how to use the spreadsheet application. It does not include information or explanation on the definitions and specifications of FCAS services. Nor does it include reasoning behind why any particular calculation is done. The MASS provides the complete definition and specification of FCAS, and users of the FCASVT and this guide are assumed to have a good understanding of the MASS.

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. 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 the table below have the meanings set out opposite them when used in these Procedures.

Table 1 Definitions

Term	Definition
Aggregated Ancillary Service Facility	The relevant plant which *ancillary service generating units* and/or *ancillary service loads* have aggregated to provide the relevant *market ancillary service*
Aggregated Generation Amount	means the amount of power flow through one or more *connection points* of an aggregated *ancillary service generating unit*, measured in megawatts (MW), with flow from the *ancillary service generating unit* being positive
Aggregated Load Amount	means the amount of power flow through one or more *connection points* of an aggregated *ancillary service load*, measured in MW, with flow towards the *ancillary service load* being negative
Ancillary Service Facility	The *ancillary service generating unit* and/or *ancillary service load* used to provide the relevant *market ancillary service*
Contingency Event Time	The time at which the *contingency event* occurred. This is a value determined by AEMO in accordance with the process in section Error! Reference source not found..
Contingency Services	means the (1) the *fast raise service*; (2) the *fast lower service*; (3) the *slow raise service*; (4) the *slow lower service*; (5) the *delayed raise service*; and (6) the *delayed lower service*

Term	Definition
Controlled Quantity	means a measured quantity of *generation* or *load* that is: (a) controlled by the action of Raise Signals and Lower Signals; (b) measured and transmitted to *AEMO*'s control centre; and (c) unless otherwise agreed between *AEMO* and the relevant *Market Participant*, the same quantity specified in a *dispatch bid* or *dispatch offer* of the Ancillary Service Facility
Frequency Control Ancillary Services (FCAS)	means those *ancillary services* concerned with balancing, over short intervals (shorter than the dispatch interval), the power supplied by *generating units* and the power consumed by *loads*. Procured as *market ancillary services*
Frequency Control Ancillary Service Ancillary Service Verification Tool (FCASVT)	means the Frequency Control Ancillary Service Ancillary Service Verification Tool; an Excel spreadsheet designed to verify the performance of Contingency Services
Frequency Deadband	means the range of Local Frequency through which a Variable Controller will not operate
Frequency Deviation Setting(s)	means the setting or settings allocated to *the* Ancillary Service Facility by AEMO within the range shown in Error! Reference source not found. for *regions* other than Tasmania and Error! Reference source not found. for the Tasmania *region*
Frequency Disturbance	means an occasion when the *frequency* of the *power system* moves outside the *normal operating frequency band*
Frequency Disturbance Time	means the time at which Local Frequency falls or rises outside the *normal operating frequency band* during a Frequency Disturbance, referenced to Australian Eastern Standard Time[1]
Frequency Operating Standards	has the meaning given in the NER, as applicable to the *region* in which the relevant Ancillary Service Facility is located
Frequency Ramp Rate	means 0.125 hertz (Hz) per second for *regions* other than Tasmania or 0.4 Hz per second for the Tasmanian *region*
Frequency Rate of Change Multiplier	means a value in Error! Reference source not found. for *regions* other than Tasmania, or Error! Reference source not found. for the Tasmanian *region*, which corresponds to the allocated Frequency Setting
Frequency Recovery	means the first change in Local Frequency from above 50.15 Hz to below 50.1 Hz, or below 49.85 Hz to above 49.9 Hz, to occur after a Frequency Disturbance
Frequency Setting(s)	means the level(s) of *frequency* or a combined level(s) of *frequency* and *frequency* rate of change determined by *AEMO* in accordance with the procedure set out in section Error! Reference source not found. and notified in writing to the *Market Participant* for use by a Switching Controller or a *combined* Switching Controller for a particular Ancillary Service Facility when providing a particular *market ancillary service*
Generation Amount	means the amount of power flow through a *connection point* of an *ancillary service generating unit*, measured in MW, with flow from the *ancillary service generating unit* being positive
Generation Event	has the meaning given or implied in the relevant Frequency Operating Standards
Inertial Response	means the change in Generation Amount or Load Amount due to the effect of the inertia of the Ancillary Service Facility
Initial Value	means the Generation Amount or Load Amount prior to the Contingency Event Time prior to a Frequency Disturbance

[1] The Frequency Disturbance Time is referred to in the equations in the MASS as occurring at t = 0.

Term	Definition
Load Amount	means the amount of power flow through a *connection point* of an *ancillary service load*, measured in MW, with flow towards the *ancillary service load* being negative
Load Event	has the meaning given or implied in the relevant Frequency Operating Standards
Local Frequency	means the *frequency* of the electricity measured by an *ancillary service generating unit* or consumed by an *ancillary service load*, measured in Hz
Lower Control Limit	means the lowest level to which a Controlled Quantity may be controlled in response to Lower Signals, as transmitted to *AEMO's* control centre
Lower Rate Limit	means the highest rate at which a Controlled Quantity may be controlled in response to Lower Signals, as transmitted to *AEMO's* control centre
Lower Reference Frequency	means the containment frequency above 50 Hz for Load Events, as given in the relevant Frequency Operating Standards
Lower Response	means the decrease in Generation Amount or increase in Load Amount with respect to the corresponding Initial Value
Lower Signal	means a control signal sent by or on behalf of *AEMO* in a form agreed between *AEMO* and the relevant *Market Participant* in order to request delivery of Regulating Lower Response
Operational Frequency Tolerance Band	has the meaning given in the NER and the value given in the relevant *frequency operating standard*
Raise Control Limit	means the highest level to which a Controlled Quantity may be controlled in response to Raise Signals, as transmitted to *AEMO's* control centre
Raise Rate Limit	means the highest rate at which a Controlled Quantity may be controlled in response to Raise Signals, as transmitted to *AEMO's* control centre
Raise Reference Frequency	means the containment frequency below 50 Hz for Generation Events, as given in the relevant Frequency Operating Standards
Raise Response	means the increase in Generation Amount or decrease in Load Amount with respect to the corresponding Initial Value
Raise Signal	means a control signal sent by or on behalf of *AEMO* in a form agreed between *AEMO* and the relevant *Market Participant* in order to request delivery of Regulating Raise Response
Regulating Lower Response	means the decrease in Generation Amount or increase in Load Amount delivered in response to one or more Lower Signals
Regulating Raise Response	means the increase in Generation Amount or decrease in Load Amount delivered in response to one or more Raise Signals
Standard Frequency Ramp	means a linear change of Local Frequency from one level to another at the applicable Frequency Ramp Rate and then sustained, as shown in Error! Reference source not found..
Switching Controller	means a *control system* that delivers a specific amount of service when one or more specified conditions are met
System Frequency	means a *frequency* measured by or for *AEMO* that represents the *frequency* of the *power system* to which the Ancillary Service Facility is connected
Time Average	means, in respect of 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 time interval duration

Term	Definition
Trigger Range	means the contiguous range comprising the upper 40% of the range between 50 Hz and the Raise Reference Frequency and the lower 40% of the range between 50 Hz and the Lower Reference Frequency
Trigger Rate	means 0.05 Hz per second for *regions* other than Tasmania and 0.15 Hz per second for the Tasmanian *region*
Variable Controller	means a *control system* that delivers a variable amount of *market ancillary service* commensurate with the size of the Frequency Disturbance
Lower Response	means the decrease in Generation Amount or increase in Load Amount with respect to the corresponding Initial Value
Lower Signal	means a control signal sent by or on behalf of *AEMO* in a form agreed between *AEMO* and the relevant *Market Participant* in order to request delivery of Regulating Lower Response
Operational Frequency Tolerance Band	has the meaning given in the NER and the value given in the relevant *frequency operating standard*
Raise Control Limit	means the highest level to which a Controlled Quantity may be controlled in response to Raise Signals, as transmitted to *AEMO*'s control centre
Raise Rate Limit	means the highest rate at which a Controlled Quantity may be controlled in response to Raise Signals, as transmitted to *AEMO*'s control centre
Raise Reference Frequency	means the containment frequency below 50 Hz for Generation Events, as given in the relevant Frequency Operating Standards
Raise Response	means the increase in Generation Amount or decrease in Load Amount with respect to the corresponding Initial Value
Raise Signal	means a control signal sent by or on behalf of *AEMO* in a form agreed between *AEMO* and the relevant *Market Participant* in order to request delivery of Regulating Raise Response
Regulating Lower Response	means the decrease in Generation Amount or increase in Load Amount delivered in response to one or more Lower Signals
Regulating Raise Response	means the increase in Generation Amount or decrease in Load Amount delivered in response to one or more Raise Signals
Standard Frequency Ramp	means a linear change of Local Frequency from one level to another at the applicable Frequency Ramp Rate and then sustained, as shown in Error! Reference source not found..
Switching Controller	means a *control system* that delivers a specific amount of service when one or more specified conditions are met
System Frequency	means a *frequency* measured by or for *AEMO* that represents the *frequency* of the *power system* to which the Ancillary Service Facility is connected
Time Average	means, in respect of 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 time interval duration
Trigger Range	means the contiguous range comprising the upper 40% of the range between 50 Hz and the Raise Reference Frequency and the lower 40% of the range between 50 Hz and the Lower Reference Frequency
Trigger Rate	means 0.05 Hz per second for *regions* other than Tasmania and 0.15 Hz per second for the Tasmanian *region*
Variable Controller	means a *control system* that delivers a variable amount of *market ancillary service* commensurate with the size of the Frequency Disturbance

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) References to time are references to Australian Eastern Standard Time.

1.3. Related documents

The FCASVT and User Guide are implementations of the principles set out in the MASS. If there is any inconsistency between the FCASVT and the MASS, the MASS will prevail to the extent of that inconsistency.

Table 2 Related documents

Title	Location
Market Ancillary Services Specification	http://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/market-ancillary-services-specification-and-fcas-verification-tool
FCAS Verification Tool	
Guide to Ancillary Services in the National Electricity Market	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services

2. DESCRIPTION OF VERIFICATION TOOL PROCESS

Clauses 3.6, 4.6 and 5.6 of the MASS contain the principles that must be followed in verifying the response of *ancillary service generating units* and *ancillary service loads* enabled to provide Contingency Services. This clause details the steps taken verifying this response. These steps are embodied in the FCASVT. If there is any inconsistency between this clause and the MASS, the MASS will prevail to the extent of that inconsistency.

2.1. Verification of Fast Raise Service and Fast Lower Service

For the purpose of verifying the amount of *fast raise service* or *fast lower service* delivered in response to a change in *local frequency*, the amount of service to be compared with the *enabled price bands* or maximum capability of the relevant *market ancillary service offer* must be determined using the recordings made under clause 3.6 of the MASS as follows:

(a) Perform the following steps:

(i) for the purpose of clause 2.1(a)(ii), if the *ancillary service generating unit* or *ancillary service load* is *scheduled* or *semi-scheduled* then determine its reference trajectory as the successive straight line interpolations of the initial metered loading at the beginning of a dispatch interval to the expected *dispatch* target or *dispatch level* at the end of the dispatch interval. The reference trajectory is to start with the initial loading at the beginning of the dispatch interval in which the frequency deviation occurs and is to continue for the succeeding two dispatch intervals[2].

(ii) determine a set of values RT such that:

[2] For example if a frequency event occurs at 01:04 hrs then the associated reference trajectory will be the straight line interpolations between the initial loadings measured at the beginning of the 01:05, 01:10, and 01:15 *dispatch intervals* to the dispatch targets corresponding with the 01:05, 01:10, and 01:15 *dispatch intervals*.

if the *ancillary service generating unit* or *ancillary service load* is a *scheduled generating unit* or *scheduled load or semi-scheduled generating unit* respectively, RT_i is equal to:

RT0 minus the value of the reference trajectory at time t_i, corresponding to the power measurement P_i

where: RT0 is the value of the reference trajectory at the *Contingency Event Time*

(iii) adjust each power measurement (P_i at time interval i) after the *Contingency Event Time* for changing *dispatch* targets by first adding to it:

the maximum of RT_i and 0 if *local frequency* was below 50 Hz at the *Contingency Event Time*

the minimum of RT_i and 0 if *local frequency* was above 50 Hz at the *Contingency Event Time*

(iv) add to each adjusted power measurement an amount of:

$IR_i = 4\,\pi^2\, I\, f_i\, df/dt_i$

where IR_i is the *inertial response* at time t_i,

I is the effective moment of inertia of the *ancillary service generating unit* or *ancillary service load* as agreed between *AEMO* and the relevant *Market Participant*,

f_i is the measurement of *local frequency* at time t_i corresponding to the power measurement at time t_i,

f_{local} is smoothed using the following process

$f_{local,i-10}=f_{local-offset,i} = 0.9^* f_{local-offset,i-1} + 0.1^* f_{metered-offset,i}$

where $f_{metered-offset,i}$ is the measurement of *local frequency* at time t_i

$f_{local-offset,i}$ is the offset smoothed *local frequency* at time t_i,

$f_{local,i}$ is the smoothed *local frequency* at time t_i.

and

df/dt_i is the rate of change of smoothed *local frequency* at time t_i

(v) determine value FA as the *time average* of the adjusted power measurements made during the period between twenty seconds and eight seconds before the *frequency disturbance time*;

(vi) determine the basic response measurements by subtracting value FA from each adjusted power measurement after the *Contingency Event Time*;

(vii) determine the values FP and FS such that:

FS is the amount of the basic response delivered by *switching controller*, and FP is the amount of the basic response delivered by *variable controller*. If a discrete combination of *switching controller* and *variable controller* is used (refer clause 3.6(b) of the MASS) then FS is determined by separate metering or appropriate control system data, and FP is determined by subtracting FS from the total basic response.

(viii) compensate each value of FP after the *Contingency Event Time* for *frequency* change by multiplying it by the following factor, disregarding any measurement at or after a *frequency recovery*:

$$MIN\left(MAX\left(1, \frac{ABS(f_{raise\ DB} - f_{resp-rate})}{ABS(f_{raise\ DB} - f_{local})}\right), 3\right) \times G$$

if f_{local} less than 50 Hz, or:

$$MIN\left(MAX\left(1, \frac{ABS(f_{lower\ DB} - f_{resp-rate})}{ABS(f_{lower\ DB} - f_{local})}\right), 3\right) \times G$$

if f_{local} greater than 50 Hz

where f_{local} is the *local frequency* measurement coincident with the basic response measurement being compensated,

f_{local} is smoothed using the following process

$f_{local,i-10} = f_{local-offset,i} = 0.9 * f_{local-offset,i-1} + 0.1 * f_{metered-offset,i}$

where $f_{metered-offset,i}$ is the measurement of *local frequency* at time t_i

$f_{local-offset,i}$ is the offset smoothed *local frequency* at time t_i,

$f_{local,i}$ is the smoothed *local frequency* at time t_i.

$f_{raise\ DB}$ is the lower frequency of the controller's *frequency dead-band*

$f_{lower\ DB}$ is the higher frequency of the controller's *frequency dead-band*

if f_{local} less than 50 Hz then

$$frequency\ reference\ time = \frac{49.85 - f_{ref}}{frequency\ ramp\ rate}$$

if f_{local} greater than 50 Hz then

$$frequency\ reference\ time = \frac{f_{ref} - 50.15}{frequency\ ramp\ rate}$$

if time after the event is between 0 and *frequency reference time* and f_{local} less than 50 Hz then:

$f_{resp-rate}$ = 49.85 – t * *frequency ramp rate*

if time after the event is between 0 and *frequency reference time* and f_{local} greater than 50 Hz then:

$f_{resp-rate}$ = 50.15 + t * the appropriate *frequency ramp rate*

if time after the event is greater than *frequency reference time* and f_{local} less than 50 Hz then:

$f_{resp-rate}$ = the appropriate *raise reference frequency*

if time after the event is greater than *frequency reference time* and f_{local} greater than 50 Hz then:

$f_{resp-rate}$ = the appropriate *lower reference frequency*

f_{ref} is the appropriate *raise* or *lower reference frequency*

frequency ramp rate is the appropriate *MASS* defined *frequency ramp rate*

MIN (x,y) means the function of the minimum of x and y, MAX (x,y) means the function of the greater of x and y, and

ABS(x) means the function of the absolute value of x;

$G = T_{reg}/T_{act}$

T_{reg} is the maximum capacity corresponding to the relevant registered FCAS trapezium

T_{act} is the maximum capacity corresponding to the maximum availability of the trapezium appropriate for the measured maximum rate of change of frequency that actually occurred. *Market participants* supplying *market ancillary services* would need to provide relevant information to AEMO needed to calculate T_{act}.

(ix) compensate FS by multiplying it by*:*

MAX (1, (6 - *frequency setting time)*/(6 - $t_{initiate}$ + t_{step}))

where $t_{initiate}$ is time after the event when the *local frequency* measurement reaches the relevant *frequency setting*

t_{step} is equal to the time interval between power flow measurements during the first six seconds after the *frequency disturbance time*.

(x) determine the adjusted response as FS plus FP;

(xi) determine value FB as twice the *time average* of the adjusted response measurements (after any necessary compensation) made between the *Contingency Event Time* and six seconds after the *frequency disturbance time* disregarding measurements made at or after a *frequency recovery*;

(xii) determine value FC as twice the *time average* of the adjusted response measurements (after any necessary compensation) made between six and sixty seconds after the *frequency disturbance time* but disregarding measurements made at or after a *frequency recovery*.

(b) Determine the amounts of *fast raise response* and *fast lower response* from the values of FB and FC as follows:

(i) Round the values of FB and FC to the nearest 0.1 MW;

(ii) If *local frequency* was below 50 Hz at the *frequency disturbance time*, the amount of fast *raise response* is within the range of ± 5% of the lesser of value FB and value FC;

(iii) If local *frequency* was above 50 Hz at the *frequency disturbance time*, the amount of *fast lower response* is within the range of ± 5% the negative of the greater of value FB and value FC[3]; and

(iv) For the purposes of clause 2.2(b), value FD is:

A If the power system frequency was below 50 Hz at the *frequency disturbance* time,

$FD = FC - MIN(FC, F_{enb})$; and

B If the power system frequency was above 50 Hz at the *frequency disturbance* time,

$FD = FC - MAX(FC, -F_{enb})$

where F_{enb} is the amount of fast raise/lower service enabled by *dispatch*,

MIN (x,y) means the function of the minimum of x and y, and

[3] Note that FB and FC are negative values.

MAX (x,y) means the function of the greater of x and y.

(c) If two or more *ancillary service generating units* or *ancillary service loads* that share a common *connection point* were *enabled* for the same *market ancillary service* at the time of the *frequency disturbance*, allocate the responses determined in paragraphs (b)(i) and (b)(ii) above to each of them in proportion to the corresponding amounts of *raise response* or *lower response* that they should have delivered taking into account:

(i) the amounts for which they were *enabled*; and

(ii) if the *ancillary service generating units* or *ancillary service loads* use *switching controllers*, the actual *frequency* trajectory compared with the *frequency* setting of each relevant *switching controller*.

(d) If at the time of the *frequency disturbance* the maximum service capability of the *ancillary services generating unit* or *ancillary services load* is less than *enabled price bands*, then the expected service delivery is equal to the maximum service capability.

The maximum *fast raise service* capability is equal to the *ancillary services generating unit* or *ancillary services load's bid fast raise service* capability that corresponds to FA.

The maximum *fast lower service* capability is equal to the *ancillary services generating unit* or *ancillary services load's* bid *fast lower service* capability that corresponds to FA.

2.2. Verification of Slow Raise Service and Slow Lower Service

For the purpose of verifying the amount of *slow raise service* or *slow lower service* delivered in response to a change in *local frequency*, the amount of service to be compared with the *enabled price bands* or maximum capacity of the relevant *market ancillary service offer* must be determined using the recordings made under clause 4.6 of the MASS as follows:

(a) Perform the following steps:

(i) for the purpose of clause 2.2(a)(ii), if the *ancillary service generating unit* or *ancillary service load* is *scheduled* or *semi-scheduled* then determine its reference trajectory as the successive straight line interpolations of the initial metered loading at the beginning of a dispatch interval to the expected *dispatch* target or *dispatch level* at the end of the dispatch interval. The reference trajectory is to start with the initial loading at the beginning of the dispatch interval in which the frequency deviation occurs and is to continue for the succeeding two dispatch intervals[4].

(ii) determine a set of values RT such that:

if the *ancillary service generating unit* or *ancillary service load* is a *scheduled generating unit* or *scheduled load or semi-scheduled generating unit* respectively, RT_i is equal to:

RT0 minus the value of the reference trajectory at time t_i, corresponding to the power measurement P_i

where: RT0 is the value of the reference trajectory at the time of the *frequency disturbance*

[4] For example if a frequency event occurs at 01:04 hrs then the associated reference trajectory will be the straight line interpolations between the initial loadings measured at the beginning of the 01:05, 01:10, and 01:15 *dispatch intervals* to the dispatch targets corresponding with the 01:05, 01:10, and 01:15 *dispatch intervals*.

(iii) adjust each power measurement (P_i at time interval i) after the *frequency disturbance* for changing *dispatch* targets by first adding to it:

the maximum of RT_i and 0 if *local frequency* was below 50 Hz at the *frequency disturbance time*

the minimum of RT_i and 0 if *local frequency* was above 50 Hz at the *frequency disturbance time*

(iv) if the measurements conform to the requirements of clause 3.6(a)(iii) of the MASS, adjust each adjusted power measurement made until 60 seconds after the *frequency disturbance time* in accordance with the procedure given in clause 2.1(a)(iv)

(v) determine value SA as the *time average* of the adjusted power measurements made during the period between twenty seconds and eight seconds before the *frequency disturbance time*;

(vi) determine the basic response measurements by subtracting value SA from each power measurement (as adjusted) after the *frequency disturbance time*;

(vii) determine the values SP and SS such that:

SS is the amount of the basic response delivered by *switching controller*, and SP is the amount of the basic response delivered by *variable controller*. If a discrete combination of *switching controller* and *variable controller* is used (refer clause 4.6(b) of the MASS) then SS is determined by separate metering or appropriate *control system* data, and SP is determined by subtracting SS from the total basic response.

(viii) compensate each value of SP for *frequency* change by multiplying it by the following factor, disregarding measurements made at or after a *frequency recovery*:

$$MIN\left(MAX\left(1,\frac{ABS\left(f_{raise\ DB}-f_{resp-rate}\right)}{ABS\left(f_{raise\ DB}-f_{local}\right)}\right),3\right)\times G$$

if f_{local} less than 50 Hz, or:

$$MIN\left(MAX\left(1,\frac{ABS\left(f_{lower\ DB}-f_{resp-rate}\right)}{ABS\left(f_{lower\ DB}-f_{local}\right)}\right),3\right)\times G$$

if f_{local} greater than 50 Hz

where f_{local} is the *local frequency* measurement coincident with the basic response measurement being compensated,

f_{local} is smoothed using the following process

$f_{local,i-10}=f_{local-offset,i} = 0.9^* f_{local-offset,i-1} + 0.1^* f_{metered-offset,i}$

where $f_{metered-offset,i}$ is the measurement of *local frequency* at time t_i

$f_{local-offset,i}$ is the offset smoothed *local frequency* at time t_i,

$f_{local,i}$ is the smoothed *local frequency* at time t_i.

$f_{raise\ DB}$ is the lower frequency of the controller's *frequency dead-band*

$f_{lower\ DB}$ is the higher frequency of the controller's *frequency dead-band*

if f_{local} less than 50 Hz then $$frequency\ reference\ time = \frac{49.85 - f_{ref}}{frequency\ ramp\ rate}$$

if f_{local} greater than 50 Hz then $$frequency\ reference\ time = \frac{f_{ref} - 50.15}{frequency\ ramp\ rate}$$

if time after the event is between 0 and *frequency reference time* and f_{local} less than 50 Hz then:

$f_{resp\text{-}rate}$ = 49.85 – t * *frequency ramp rate*

if time after the event is between 0 and *frequency reference time* and f_{local} greater than 50 Hz then:

$f_{resp\text{-}rate}$ = 50.15 + t * the appropriate *frequency ramp rate*

if time after the event is greater than *frequency reference time* and f_{local} less than 50 Hz then:

$f_{resp\text{-}rate}$ = the appropriate *raise reference frequency*

if time after the event is greater than *frequency reference time* and f_{local} greater than 50 Hz then:

$f_{resp\text{-}rate}$ = the appropriate *lower reference frequency*

f_{ref} is the appropriate *raise* or *lower reference frequency*

frequency ramp rate is the appropriate *MASS* defined *frequency ramp rate*

MIN (x,y) means the function of the minimum of x and y,

MAX (x,y) means the function of the greater of x and y, and

ABS(x) means the function of the absolute value of x;

G = T_{reg}/T_{act}

T_{reg} is the maximum capacity corresponding to the relevant registered FCAS trapezium

T_{act} is the maximum capacity corresponding to the maximum availability of the trapezium appropriate for the measured maximum rate of change of frequency that actually occurred. *Market participants* supplying *market ancillary services* would need to provide relevant information to AEMO needed to calculate T_{act}.

(ix) determine the adjusted response as SS plus SP;

(x) determine value SB as twice the *time average* of the adjusted response measurements (after any necessary compensation) made between six and sixty seconds after the *frequency disturbance time* disregarding measurements made at or after a *frequency recovery*;

(xi) determine value SC as twice the *time average* of the adjusted response measurements (after any necessary compensation) made between sixty seconds and five minutes after the *frequency disturbance time* disregarding measurements made at or after a *frequency recovery* or after a *service cancellation*.

(b) Determine the amounts of *slow raise response* and *slow lower response* from the values of SB and SC as follows:

(i) Round the values of SB and SC to the nearest 0.1 MW;

(ii) If *local frequency* was below 50 Hz at the *frequency disturbance time*, determine the amount of *slow raise response* as within the range of ± 5% of the lesser of value SC and:

A if the *ancillary service generating unit* or *ancillary service load* was not *enabled* for a *fast raise service,* value SB; and

B otherwise, the greater of zero and value FD determined under clause 2.1(b)(iv);

(iii) If *local frequency* was above 50 Hz at the *frequency disturbance time*, determine the amount of *slow lower response* as within the range of ± 5% of the negative of the greater of value SC and:

A if the *ancillary service generating unit* or *ancillary service load* was not *enabled* for a *fast lower service,* value SB; and

B otherwise, the lesser of zero and value FD determined under clause 2.1(b)(iv); and

(iv) For the purposes of clause 2.3(b), value SE is:

A If the power system frequency was below 50 Hz at the *frequency disturbance* time,

$SE = SC - MIN(SC, S_{enb})$; and

B If the power system frequency was above 50 Hz at the *frequency disturbance* time,

$SE = SC - MAX(SC, -S_{enb})$

where S_{enb} is the amount of slow raise/lower service enabled by *dispatch*,

MIN (x,y) means the function of the minimum of x and y, and

MAX (x,y) means the function of the greater of x and y.

(c) If two or more *ancillary service generating units* or *ancillary service loads* that share a common *connection point* were *enabled* for the same service at the time of the *frequency disturbance*, allocate the responses determined in paragraphs (b)(i) and (b)(ii) above to each of them in proportion to the corresponding amounts of *raise response* or *lower response* that they should have delivered taking into account:

(i) the amounts for which they were *enabled*; and

(ii) if the *ancillary service generating units* or *ancillary service loads* have switching controllers, the actual *frequency* trajectory compared with the *frequency setting* of each relevant *switching controller*.

(d) If at the time of the frequency disturbance the maximum service capability of the *ancillary services generating unit* or *load* is less than *enabled price bands*, then the expected service delivery is equal to the maximum service capability.

The maximum *slow raise service* capability is equal to the *ancillary services generating unit* or *load's bid fast raise service* capability that corresponds to SA.

The maximum *slow lower service* capability is equal to the *ancillary services generating unit* or *load's bid fast lower service* capability that corresponds to SA.

2.3. Verification of Delayed Raise Service and Delayed Lower Service

For the purpose of verifying the amount of *delayed raise service* or *delayed lower service* delivered in response to a change in *local frequency*, the amount of service to be compared with the *enabled price bands* or maximum capacity of the relevant *market ancillary service offer* must be determined using the recordings made under clause 5.6 of the MASS as follows:

(a) Perform the following steps:

(i) for the purpose of clause 2.3(a)(ii), if the *ancillary service generating unit* or *ancillary service load* is *scheduled* or *semi-scheduled* then determine its reference trajectory as the successive straight line interpolations of the initial metered loading at the beginning of a dispatch interval to the expected *dispatch* target or *dispatch level* at the end of the dispatch interval. The reference trajectory is to start with the initial loading at the beginning of the dispatch interval in which the frequency deviation occurs and is to continue for the succeeding two dispatch intervals[5].

(ii) determine a set of values RT such that:

if the *ancillary service generating unit* or *ancillary service load* is a *scheduled generating unit* or *scheduled load or semi-scheduled generating unit* respectively, RT_i is equal to:

RT0 minus the value of the reference trajectory at time t_i, corresponding to the power measurement P_i

where: RT0 is the value of the reference trajectory at the time of the frequency disturbance

(iii) adjust each power measurement (P_i at time interval i) after the *frequency disturbance* for changing *dispatch* targets by first adding to it:

the maximum of RT_i and 0 if *local frequency* was below 50 Hz at the *frequency disturbance time*

the minimum of RT_i and 0 if *local frequency* was above 50 Hz at the *frequency disturbance time*

(iv) determine value DA as the *time average* of the power measurements made during the period between twenty seconds and eight seconds before the *frequency disturbance time*;

(v) determine the basic response measurements by subtracting value DA from each power measurement after the *frequency disturbance time*;

(vi) determine value DB as twice the *time average* of the basic response measurements made between one and five minutes after the *frequency disturbance time* disregarding measurements made at or after a *frequency recovery* or after *service cancellation*;

(vii) determine value DC as the *time average* of the basic response measurements made between five minutes and ten minutes after the *frequency disturbance time* disregarding measurements made at or after a *frequency recovery* or after *service cancellation*.

(b) Determine the amounts of *delayed raise response* and *delayed lower response* from the values of DB and DC as follows:

(i) Round the values of DB and DC to the nearest 0.1 MW;

---

[5] For example if a frequency event occurs at 01:04 hrs then the associated reference trajectory will be the straight line interpolations between the initial loadings measured at the beginning of the 01:05, 01:10, and 01:15 *dispatch intervals* the dispatch targets corresponding with the 01:05, 01:10, and 01:15 *dispatch intervals*.

(ii) If *local frequency* was below 50 Hz at the *frequency disturbance time*, determine the amount of *delayed raise response* as within the range of ± 5% of the lesser of value DC and:

A if the *ancillary service generating unit* or *ancillary service load* was not *enabled* for a *slow raise service,* value DB; and

B otherwise, the greater of zero and value SE determined under clause 2.2(b)(iv);

(iii) If *local frequency* was above 50 Hz at the *frequency disturbance time*, determine the amount of *delayed lower response* as within the range of ± 5% of the negative of the greater of value DC and:

A if the *ancillary service generating unit* or *ancillary service load* was not *enabled* for a *slow lower service*, value DB; and

B otherwise, the lesser of zero and value SE determined under clause 2.2(b)(iv).

(c) If two or more *ancillary service generating units* or *ancillary service loads* that share a common *connection point* were *enabled* for the same service at the time of the *frequency disturbance*, allocate the responses determined in paragraphs (b)(i) and (b)(ii) above to each of them in proportion to the corresponding amounts of response that they should have delivered taking into account:

(i) the amounts for which they were *enabled*; and

(ii) if the *ancillary service generating units* or *ancillary service loads* have switching controllers, the actual *frequency* trajectory compared with the *frequency setting* of each relevant *switching controller*.

(d) If at the time of the *frequency disturbance* the *maximum service* capability of the *ancillary services generating unit* or *ancillary services load* is less than *enabled price bands*, then the expected *service delivery* is equal to the maximum service capability.

The maximum *delayed raise service* capability is equal to the *ancillary services generating unit* or *load's bid fast raise service* capability that corresponds to DA.

The maximum *delayed lower service* capability is equal to the *ancillary services generating unit* or *load's bid fast lower service* capability that corresponds to DA.

3. SETUP

3.1. Software pre-requisites

The FCASVT is an Excel spreadsheet and requires Microsoft Excel 2010 or a later version to be installed on the user's PC.

3.2. Downloading the application

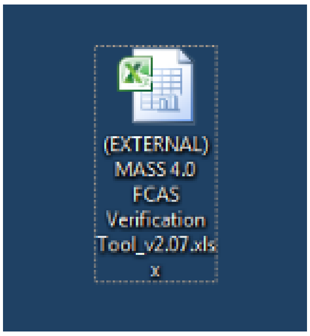
The FCASVT can be downloaded from AEMO's website at:

http://www.aemo.com.au/Electricity/Market-Operations/Ancillary-Services/Specifications-and-Standards/Frequency-Control-Ancillary-Service-Verification-Tool

3.3. Installation

There is no specific installation for the FCASVT. Once the spreadsheet is downloaded and saved on the user's PC, it can be opened by double-clicking the FCASVT icon or opening the spreadsheet from Excel.

Figure 1 MASS VT icon

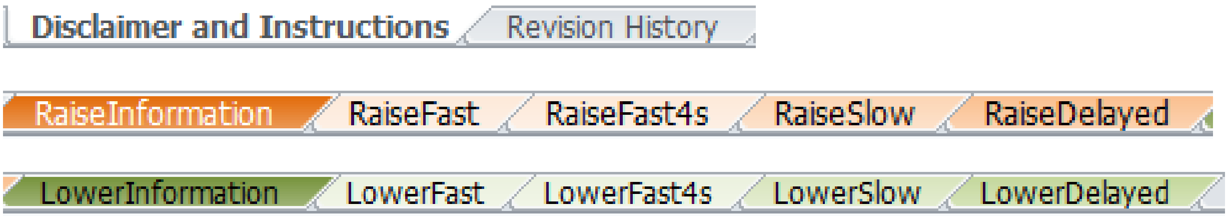


4. STRUCTURE AND FLOW OF THE FCASVT

4.1. Navigating the FCASVT

The FCASVT consists of 12 worksheet tabs as seen below.

Figure 2 Worksheet tabs



Note that for ease of use, the five "Raise" tabs are in different shades or orange, whereas the "Lower" tabs in different shades of green.

Table 3 Tab descriptions

Worksheet Tab	Description
Disclaimer and Instructions	Contains AEMO disclaimer and brief instructions on how to use the FCASVT
Revision History	Contains software updates made for each version
RaiseInformation	For Raise FCAS, the user should enter input data in this tab. Once input data is entered, the calculated R6, R60 and R5 FCAS output is displayed
RaiseFast	*This tab is for information only and no user interaction is required.* This tab contains the detailed steps to process the input data to calculation R6 services.
RaiseFast4s	*This tab is for information only and no user interaction is required.* This tab contains calculations for the sole purpose of estimating the FD parameter when high speed data is unavailable. No other information from this tab is relevant

RaiseSlow	*This tab is for information only and no user interaction is required.* This tab contains the detailed steps to process the input data to calculation R60 services.
RaiseDelayed	*This tab is for information only and no user interaction is required.* This tab contains the detailed steps to process the input data to calculation R5 services.
LowerInformation	For Lower FCAS, the user should enter input data in this tab. Once input data is entered, the calculated L6, L60 and L5 FCAS output is displayed
LowerFast	*This tab is for information only and no user interaction is required.* This tab contains the detailed steps to process the input data to calculation L6 services.
LowerFast4s	*This tab is for information only and no user interaction is required.* This tab contains calculations for the sole purpose of estimating the FD parameter when high speed data is unavailable. No other information from this tab is relevant
LowerSlow	*This tab is for information only and no user interaction is required.* This tab contains the detailed steps to process the input data to calculation L60 services.
LowerDelayed	*This tab is for information only and no user interaction is required.* This tab contains the detailed steps to process the input data to calculation L5 services.

4.2. Data and control flow

The five “Raise” tabs work together, as do the five “Lower” tabs. There is no interaction between the “Raise” and “Lower” tabs, since either a Raise or a Lower service, but not both, is delivered for a given contingency.

4.3. “Raise” tabs

The “Raise” tabs reference each other in the following order to produce the results.

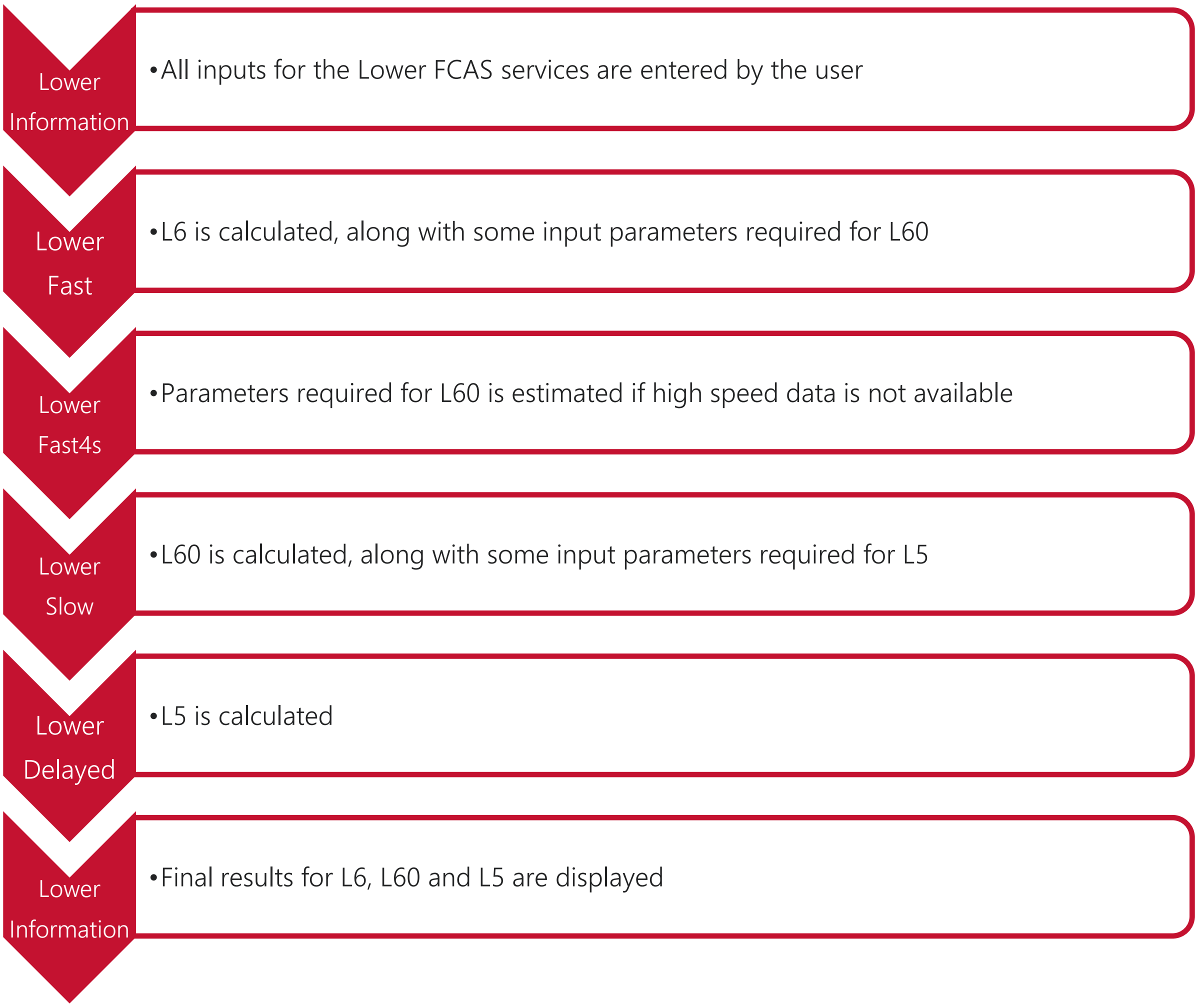
Figure 3 FCAS VT calculation process - Raise

Raise Information	•All inputs for the Raise FCAS services are entered by the user
Raise Fast	•R6 is calculated, along with some input parameters required for R60
Raise Fast4s	•Parameters required for R60 is estimated if high speed data is not available
Raise Slow	•R60 is calculated, along with some input parameters required for R5
Raise Delayed	•R5 is calculated
Raise Information	•Final results for R6, R60 and R5 are displayed

4.3.1. "Lower" tabs

The "Lower" tabs reference each other in the following order to produce the results.

Figure 4 Standard Frequency Ramp for Tasmania - Lower



5. USING THE FCASVT

5.1. User interaction

Of the 12 tabs in the FCASVT spreadsheet, not all tabs require interaction from the user if the intention is purely to calculate a result. Some tabs are applicable only to get a better understanding of the calculation, and user interaction with those tabs is optional.

The following diagram specifies which tabs are applicable for obtaining a result, and which tabs are applicable for gaining a better understanding of the calculation.

User interaction mandatory to obtain result

- RaiseInformation
- LowerInformation

User action optional (only to facilitate better understanding)

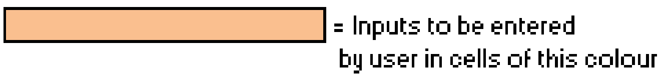
- RaiseFast
- RaiseFast4s
- RaiseSlow
- RaiseDelayed
- LowerFast
- LowerFast4s
- LowerSlow
- LowerDelayed
- Disclaimer and Instructions
- Revision History

This chapter describes tabs which require user interaction whereas clause 6 describes tabs where user interaction is optional.

5.2. Input data

In order to calculate Raise services R6, R60 and R5, the user should navigate to the "RaiseInformation" tab. To calculate Lower services L6, L60 and L5, the user should navigate to the "LowerInformation" tab

Inputs should be entered in the left side of the worksheet labelled "INPUTS". All cells in orange have to be filled in by the user.



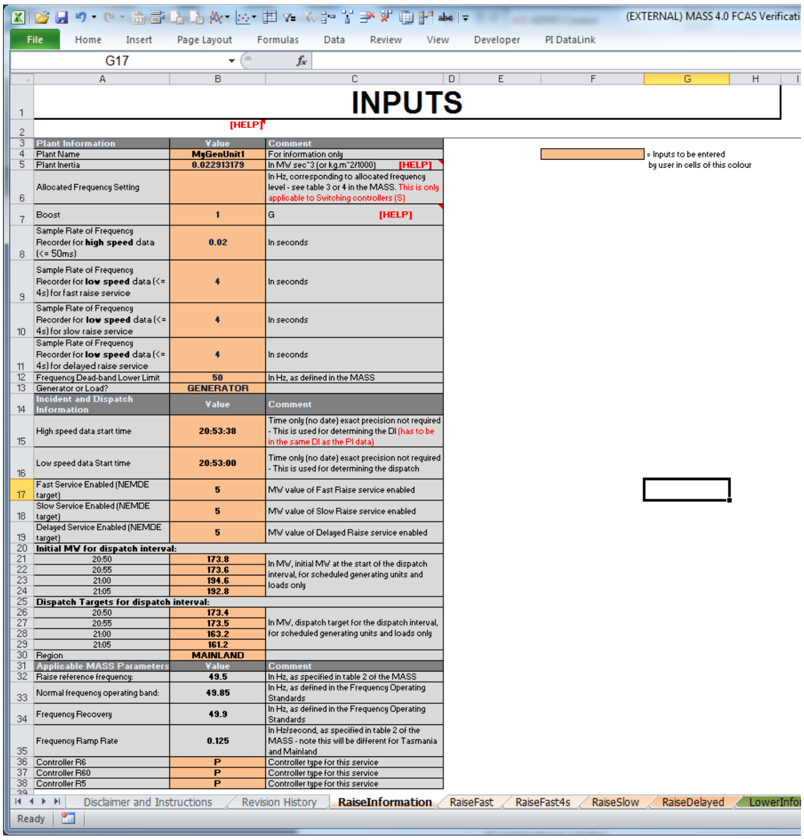
In inputs are divided into two parts

- Parameter inputs
- High/low speed data inputs

5.2.1. Parameter inputs

The parameter inputs in entered in the left table below.

Figure 5 Parameter inputs



A description of the parameter inputs are as follows:

Table 4 Input parameters

Input parameter	Description
Plant Name	DUID of the unit. This is for information only and does not impact the result
Plant Inertia	The inertia of the plant in units of $MW \cdot s^3$ (or $\frac{kg \cdot m^2}{1000}$) In order to calculate the plant inertia, use the following equation: $$Plant\ inertia = \frac{H \cdot S}{2 \cdot \pi^2 \cdot f_0^2}$$ where, H = Plant inertia constant on machine MVA base (seconds) S = Plant MVA base (MVA) f_0 = 50 Hz
Allocated Frequency Setting	In Hz, corresponding to frequency level allocated by AEMO. The frequency setting would be from table 2 or 3 of the MASS. This is only applicable to switching controllers.

Boost	This parameter is equal to 1 unless a different value as been agreed to with AEMO. Refer to clause 2.1(a)(viii).
Sample Rate of Frequency Recorder for high speed data (<= 50ms) for Fast Services	In seconds, the sample rate for high speed data (Note that the high speed data points are also an input in the bottom section of this tab). The MASS requires data for R6 and L6 services to be sample at least at 0.05s intervals. Frequently, sample rates of 0.02s are used.
Sample Rate of Frequency Recorder for low speed data (<= 4s) for estimation of the FD parameter	In seconds, the sample rate for low speed data (Note that the low speed data points are also an input in the bottom section of this tab). If a plant is enabled for fast services and high speed data is not available, then R60 and L60 cannot be calculated because the parameter FD which is an input to R60 and L60 calculation has to be calculated from high speed data. However, this spreadsheet will still calculate R60 and L60 using an estimate of FD as long as low speed data is available. This parameter specifices the sampling rate of the low speed data. Refer to clause 2.2(b) for further details.
Sample Rate of Frequency Recorder for low speed data (<= 4s) for Slow services	In seconds, the sample rate for low speed data (Note that the low speed data points are also an input in the bottom section of this tab). The MASS requires data for R60 and L60 to be sampled at least at 4s intervals.
Sample Rate of Frequency Recorder for low speed data (<= 4s) for Delayed services	In seconds, the sample rate for low speed data (Note that the low speed data points are also an input in the bottom section of this tab). The MASS requires data for R5 and L5 to be sampled at least at 4s intervals.
Frequency Dead-band Lower Limit	In Hz, the lower limit of the frequency deadband of the governor. For example, if the deadband is ±0.1 Hz, then the value to be entered is 49.9 Hz (=50-0.1 Hz)
Generator or Load?	Choose either “GENERATOR” or “LOAD” from the drop down box
High speed data start time	Enter the start time of the high speed data in 24 hour format. E.g. 20:53:38. Do not enter the date. Exact precision is not required as it is only used to determine the dispatch interval (DI) that the contingency occurred.
Low speed data Start time	Enter the start time of the low speed data in 24 hour format. E.g. 20:53:38. Do not enter the date. Exact precision is not required as it is only used to determine the dispatch interval (DI) that the contingency occurred.
Fast Service Enabled (NEMDE target)	Fast service enabled by NEMDE. This is the cleared Fast service for the DI that the contingency occurred. Enter 0 if no Fast service was cleared for the plant.
Slow Service Enabled (NEMDE target)	Slow service enabled by NEMDE. This is the cleared Slow service for the DI that the contingency occurred. Enter 0 if no Slow service was cleared for the plant.
Delayed Service Enabled (NEMDE target)	Delayed service enabled by NEMDE. This is the cleared Delayed service for the DI that the contingency occurred. Enter 0 if no Delayed service was cleared for the plant.

Initial MW for dispatch interval:	This is only a label
20:50	(The text of the label will depend on the High/Low speed data start time entered above) Enter the initial MW for the DI. This is the measured MW value at the beginning of this DI
20:55	(The text of the label will depend on the High/Low speed data start time entered above) Enter the initial MW for the DI. This is the measured MW value at the beginning of this DI
21:00	(The text of the label will depend on the High/Low speed data start time entered above) Enter the initial MW for the DI. This is the measured MW value at the beginning of this DI
21:05	(The text of the label will depend on the High/Low speed data start time entered above) Enter the initial MW for the DI. This is the measured MW value at the beginning of this DI
Dispatch Targets for dispatch interval:	This is only a label
20:50	(The text of the label will depend on the High/Low speed data start time entered above) Dispatch target for this DI.
20:55	(The text of the label will depend on the High/Low speed data start time entered above) Dispatch target for this DI.
21:00	(The text of the label will depend on the High/Low speed data start time entered above) Dispatch target for this DI.
21:05	(The text of the label will depend on the High/Low speed data start time entered above) Dispatch target for this DI.
Region	Choose either "MAINLAND" or "TASMANIA" from the drop down box
Applicable MASS Parameters	
Raise reference frequency:	These are not user inputs. Do not change
Normal frequency operating band:	

Frequency Recovery	
Frequency Ramp Rate	
Controller R6	Choose either "P" or "S" from the drop down box to indicate if the type of the R6 controller is a Variable controller (aka Proportional controller) or a switched controller. Refer to the MASS for further details.
Controller R60	Choose either "P" or "S" from the drop down box to indicate if the type of the R60 controller is a Variable controller (aka Proportional controller) or a switched controller. Refer to the MASS for further details.
Controller R5	Choose either "P" or "S" from the drop down box to indicate if the type of the R5 controller is a Variable controller (aka Proportional controller) or a switched controller. Refer to the MASS for further details.
Contingency Event Offset	Time in seconds between Contingency Event Time and Frequency Disturbance Time (NOFB crossing). Determined by AEMO for each FCAS assessment event in accordance with the MASS. Fast Service assessment window begins from Contingency Event Time. Prior to MASS v6.0 (1 July 2020) Fast Service assessment began from NOFB crossing.

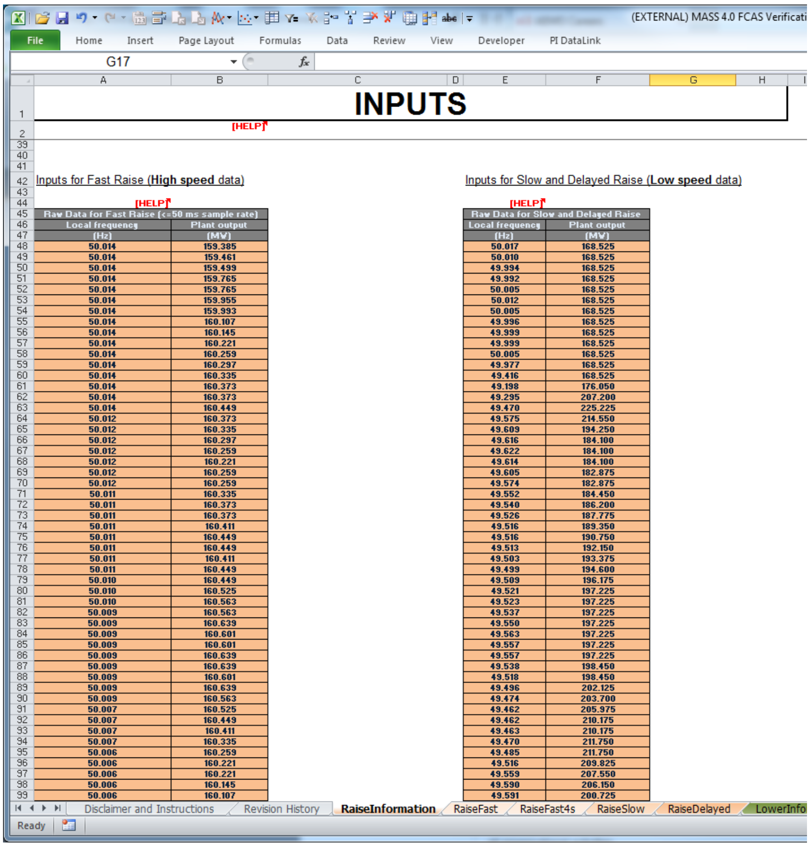
5.2.2. High/low speed data inputs

The MASS requires the following data resolution for calculating Raise and Lower services:

- R6, L6 – High speed data (sampling rate ≤ 0.05s)
- R60, L60, R5, L5 – Low speed data (sampling rate ≤ 4s)

Scroll down to find additional high/low speed data inputs:

Figure 6 High and low speed data inputs



Raw Data for Fast Raise (<=50 ms sample rate)	
Local frequency (Hz)	Plant output (MW)
50.014	159.385
50.014	159.461
50.014	159.499
50.014	159.765
50.014	159.765
50.014	159.955
50.014	159.993
50.014	160.107
50.014	160.145
50.014	160.221
50.014	160.259
50.014	160.297
50.014	160.335
50.014	160.373
50.014	160.373
50.014	160.449
50.012	160.373
50.012	160.335
50.012	160.297
50.012	160.259
50.012	160.221
50.012	160.259
50.012	160.259
50.011	160.335
50.011	160.373
50.011	160.373
50.011	160.411
50.011	160.449
50.011	160.449
50.011	160.411
50.011	160.449
50.010	160.449
50.010	160.525
50.010	160.563
50.009	160.563
50.009	160.639
50.009	160.601
50.009	160.601
50.009	160.639
50.009	160.639
50.009	160.601
50.009	160.639
50.009	160.563
50.007	160.525
50.007	160.449
50.007	160.411
50.007	160.335
50.006	160.259
50.006	160.221
50.006	160.221
50.006	160.145
50.006	160.107

Raw Data for Slow and Delayed Raise	
Local frequency (Hz)	Plant output (MW)
50.017	168.525
50.010	168.525
49.994	168.525
49.992	168.525
50.005	168.525
50.012	168.525
50.005	168.525
49.996	168.525
49.999	168.525
49.999	168.525
50.005	168.525
49.977	168.525
49.416	168.525
49.198	176.050
49.295	207.200
49.470	225.225
49.575	214.550
49.609	194.250
49.616	184.100
49.622	184.100
49.614	184.100
49.605	182.875
49.574	182.875
49.552	184.450
49.540	186.200
49.526	187.775
49.516	189.350
49.516	190.750
49.513	192.150
49.503	193.375
49.499	194.600
49.509	196.175
49.521	197.225
49.523	197.225
49.537	197.225
49.550	197.225
49.563	197.225
49.557	197.225
49.557	197.225
49.538	198.450
49.518	198.450
49.496	202.125
49.474	203.700
49.462	205.975
49.462	210.175
49.463	210.175
49.470	211.750
49.485	211.750
49.516	209.825
49.559	207.550
49.590	206.150
49.591	200.725

The user should enter high speed data on the left table and low speed data on the right table. A line in each table corresponds to a frequency and power measurement (in Hz and MW). Note that the sampling interval should be the same sampling interval specified as a parameter in the section 5.2.1.

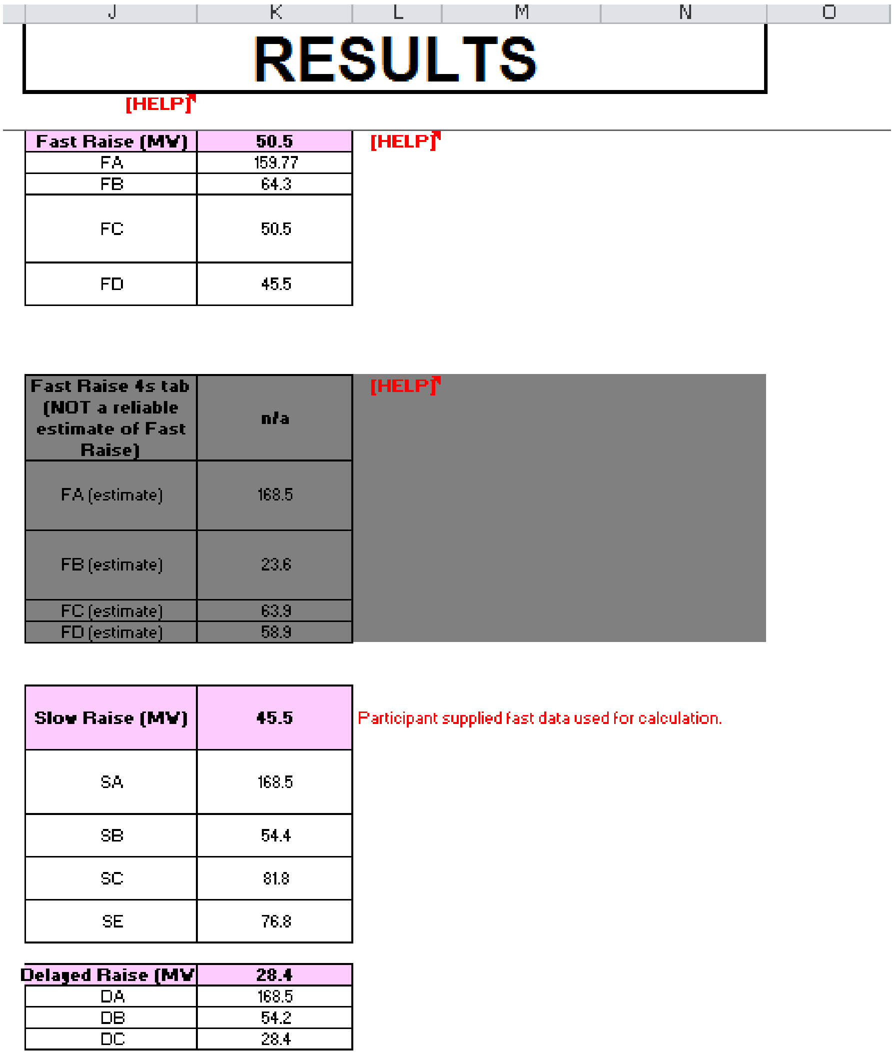
5.3. Results

The results are calculated automatically as the data in input by the user. There is no need do any further actions such as pressing a button to obtain the result.

As shown in the figure below, the results (and some intermediate parameters) are shown in the “RESULTS” section of the RaiseInformation or LowerInformation tabs.

Note that the section greyed out should be ignored. When high speed data is not available, it is used to estimate the parameter FD which is an input for L60 and R60 but requires high speed data for accurate calculation.

Figure 7 FCAS VT Results



J	K	L	M	N	O

RESULTS

[HELP]

Fast Raise (MW)	50.5
FA	159.77
FB	64.3
FC	50.5
FD	45.5

[HELP]

Fast Raise 4s tab (NOT a reliable estimate of Fast Raise)	n/a
FA (estimate)	168.5
FB (estimate)	23.6
FC (estimate)	63.9
FD (estimate)	58.9

[HELP]

Slow Raise (MW)	45.5
SA	168.5
SB	54.4
SC	81.8
SE	76.8

Participant supplied fast data used for calculation.

Delayed Raise (MW	28.4
DA	168.5
DB	54.2
DC	28.4

The user should refer to the MASS to obtain further information on the intermediate parameters such as FA, FB, FC etc.

5.4. Worked example

The downloaded version of the FCASVT comes pre-populated with a fully worked non-trivial example to show the user how data is entered into the RaiseInformation and LowerInformation tabs.

6. UNDERSTANDING THE CALCULATION STEPS IN FCASVT

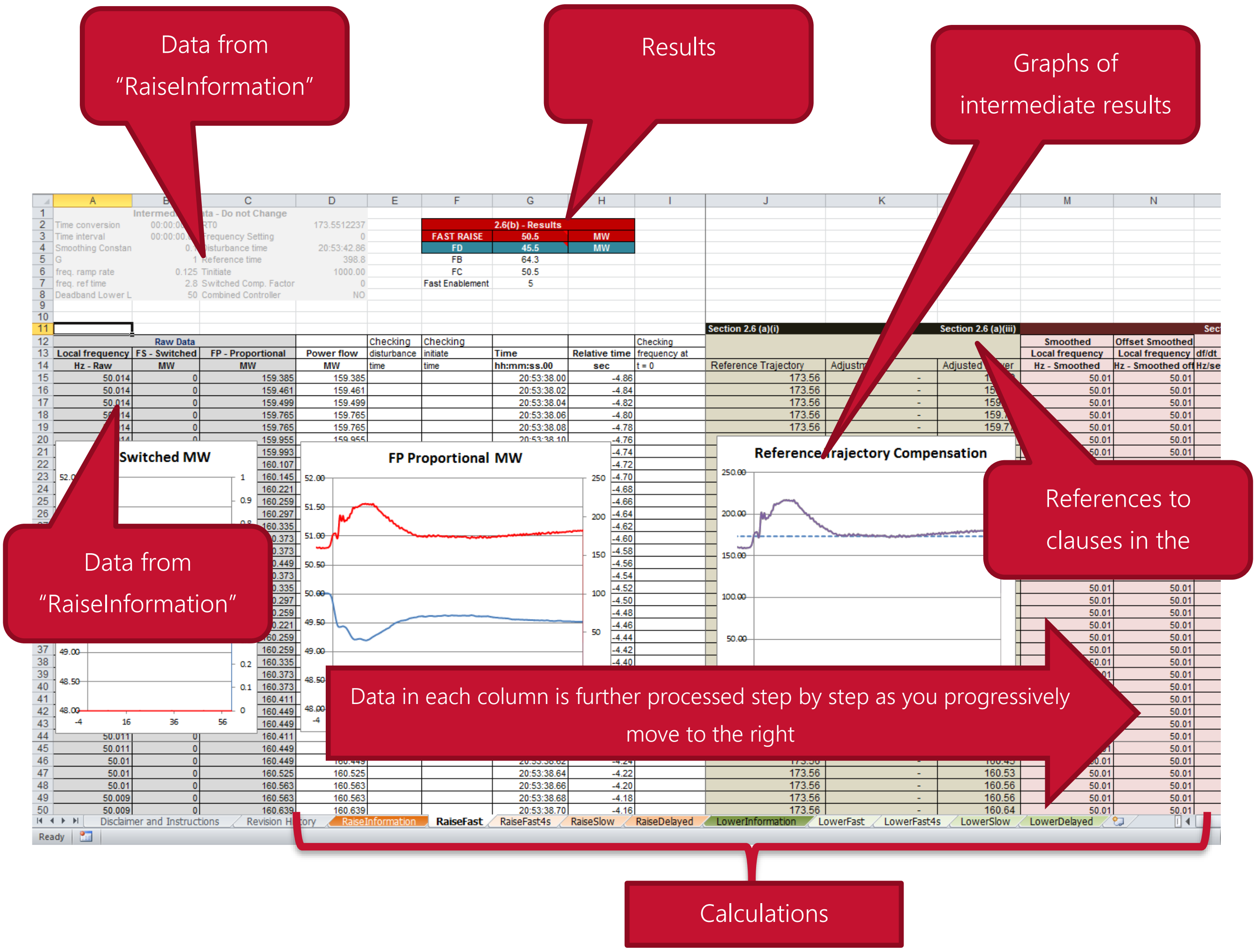
The theoretical basis for calculations in FCASVT is beyond the scope of this guide, and users should refer to the MASS for further information. A useful way gain an understanding behind the reasoning for a particular clause in the MASS is to refer to the AEMO consultation that established the clause[6].

[6] 2011: http://www.aemo.com.au/Consultations/National-Electricity-Market/Closed/Market-Ancillary-Service-Specification-MASS-Amendment-Consultation
2017: https://aemo.com.au/consultations/current-and-closed-consultations/amendment-of-the-market-ancillary-service-specification
2020: https://aemo.com.au/consultations/current-and-closed-consultations/primary-frequency-response-under-normal-operating-conditions

With sufficient understanding of the MASS, it can be instructive to follow through the calculation steps in the spreadsheet.

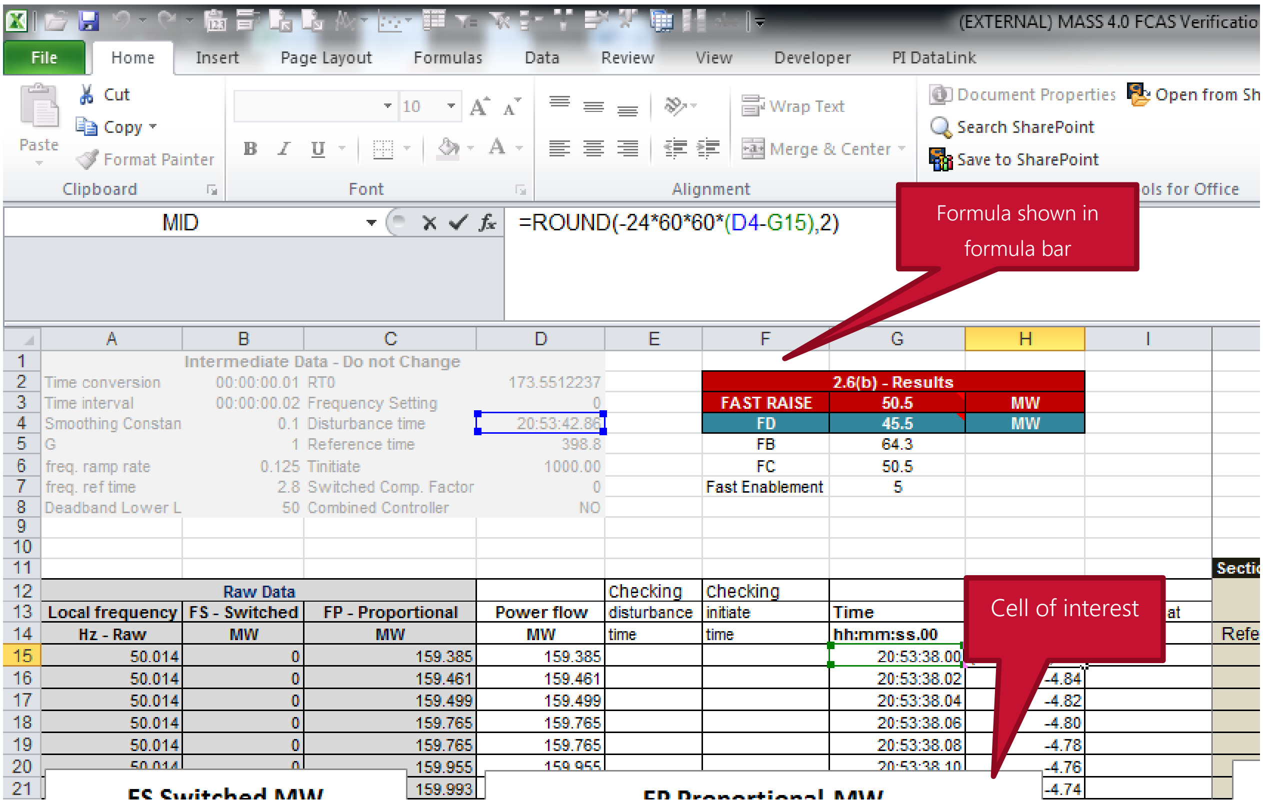
In section 4.3 and 4.3.1, the data and control flow of the calculation was briefly shown. For example, in the R6 calculation, the user first inputs the data in the "RaiseInformation" tab. In order to view the intermediate steps in the calculation, the user should navigate to the "RaiseFast" tab.

Figure 8 Calculation layout



It can be see that as the user moves progressively to the right, each column is further processed step by step as per the methodology in the MASS. The applicable clause numbers in the MASS are also identified to assist the user to locate the calculation step in the MASS. It is also instructive to consider the plots of intermediate results.

Figure 9 Calculation analysis



If the user wishes to inspect the formula behind a particular cell, place the cursor on that cell and click on the formula bar. This will show the underlying calculation as shown below. Variables are colour coded as a visual aid.

The other tabs can similarly be examined to get an understanding of how the magnitude of FCAS services is calculated.

7. SUPPORT AND INFORMATION

To report any issues or suggest improvements to either the FCASVT or this user guide, please email Freq_Event.Data@aemo.com.au.