POWER SYSTEM FREQUENCY AND TIME DEVIATION MONITORING REPORT – REFERENCE GUIDE

PREPARED BY: Electricity System Operations Planning and Performance

DOCUMENT REF: ESOPP_34

VERSION: 2.0

DATE: 2 July 2012

FINAL

Version Release History

VERSION	DATE	BY	CHANGES
5 May 2011	1.0	Diyoni Hoole	Created document
15 June 2012	2.0	Ramitha Wettimuny	Updated document to reflect changes in MASS v 4.0, and corrected some inconsistencies.

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Contents

1 Purpose of This Reference Guide

The purpose of this reference guide is to summarise the calculation process used by AEMO in the preparation of the monthly Power System Frequency and Time Deviation Monitoring reports[1].

2 Frequency Performance

AEMO is responsible for determining the quantity and nature of market ancillary services enabled to maintain the system frequency and time error within the appropriate frequency operating standards.

The market ancillary services response verification methodology shown in the graphs in this report are based on the methodology described in the Market Ancillary Services Specification (MASS) available on the AEMO web site[2]. This methodology involves averaging and scaling of values by applying a compensation factor so that the amount of market ancillary service evaluated as shown in the graphs can be significantly different to the simple measurement of responses. The magnitude of the frequency deviation is taken into account when calculating fast raise and lower services and slow raise and lower services that was delivered by market ancillary services. In some circumstances, a compensation factor is applied to magnify the plant output for instances in an event where the frequency deviation small. Market ancillary services are required to deliver the full enabled amount if the frequency exceeds the raise or lower reference frequency as specified in the MASS.

Consistent with the methodology in the MASS, calculation of the amount of service delivered depends on the period over which assessment is made.

The NEM frequency operating standards are summarised in Section 3. Guidelines for measuring the time the frequency was outside normal operating band are shown in Section 4.

The performance of enabled ancillary service generating units and ancillary service loads are presented for selected contingency events as per guidelines in Section 5.

Refer to Section 5 for the guidelines used in evaluating market ancillary service performance in the monthly Power System Frequency and Time Deviation Monitoring reports.

In the case of rapid frequency recovery to 50 Hz, the sustained delivery of slow and delayed services may not be required and this may be reflected in the assessment of these services.

Delayed raise services and delayed lower services of plant using switched controllers are only required to be provided when enabled and if the frequency excursion is outside the enabled market ancillary service's allocated frequency settings as outlined in the MASS. There are five levels of frequency settings and in the mainland and Tasmania regions[3].

Guidelines on the changes to determining the requirements for regulating raise service and regulating lower service in the NEM are outlined in Section 6.

[1] http://www.aemo.com.au/en/Electricity/Market-and-Power-Systems/NEM-Reports/Power-System-Performance-Monitoring

[2] http://www.aemo.com.au/en/Electricity/Market-and-Power-Systems/Ancillary-Services/Market-Ancillary-Service-Specification

[3] Refer to the MASS Tables 3 and 4 for the frequency settings for the Mainland and Tasmanian Regions. The MASS is available from http://www.aemo.com.au/en/Electricity/Market-and-Power-Systems/Ancillary-Services/Market-Ancillary-Service-Specification

3 Frequency Operating Standards

The frequency operating standards[4] for regions other than Tasmania are summarised in Tables 1, 2 and 3. The Tasmania region frequency operating standards are shown in Tables 4 and 5. Tables 6 and 7 depict the Rule terms for the NEM Mainland and Tasmania region respectively.

Table 1: NEM Mainland Frequency Operating Standards – Interconnected System

CONDITION	CONTAINMENT	STABILISATION	RECOVERY
Accumulated time error	5 seconds		
No contingency event or load event	49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99 % of time	49.85 to 50.15 Hz within 5 minutes	
Generation event or load event	49.5 to 50.5 Hz	49.85 to 50.15 Hz within 5 minutes	
Network Event	49.0 to 51.0 Hz	49.5 to 50.5 Hz within 1 minute	49.85 to 50.15 Hz within 5 minutes
Separation Event	49.0 to 51.0 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes
Multiple Contingency Event	47.0 to 52.0 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes

Table 2: NEM Mainland Frequency Operating Standards – Island System

CONDITION	CONTAINMENT	STABILISATION	RECOVERY
No contingency event or load event	49.5 to 50.5 Hz		
Generation event, load event or network event	49.0 to 51.0 Hz	49.85 to 50.15 Hz within 5 minutes	
The separation event that formed the island	49.0 to 51.0 Hz [5]	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes
Multiple Contingency Event including a further separation event	47.0 to 52.0 Hz	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes

Table 3: NEM Mainland Frequency Operating Standards – During Supply Scarcity

CONDITION	CONTAINMENT	STABILISATION	RECOVERY
No contingency event or load event	49.5 to 50.5 Hz		
Generation event, load event or network event	48 to 52 Hz (Queensland and South Australia) 48.5 to 52 Hz (New South Wales and Victoria)	49 to 51 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes
Multiple contingency event or separation event	47 to 52 Hz	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes

[4] The frequency operating standards for the mainland and Tasmania regions are available from http://www.aemc.gov.au/Panels-and-Committees/Reliability-Panel/Guidelines-and-standards.html

[5] Or a wider band notified to AEMO by a relevant Jurisdictional Coordinator.

Table 4: Tasmanian Frequency Operating Standards – Interconnected System

CONDITION	CONTAINMENT	STABILISATION	RECOVERY
Accumulated time error (other than multiple contingency events)	15 seconds		
Normal	49.75 to 50.25 Hz 49.85 to 50.15 Hz 99 % of time	49.85 to 50.15 Hz within 5 minutes	
Load and Generation Event	48.0 to 52.0 Hz	49.85 to 50.15 Hz within 10 minutes	
Network Event	48.0 to 52.0 Hz	49.85 to 50.15 Hz within 10 minutes	
Separation Event	47.0 to 55.0 Hz	48.0 to 52.0 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes
Multiple Contingency Event	47.0 to 55.0 Hz	48.0 to 52.0 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes

Table 5: Tasmanian Frequency Operating Standards – Island System

CONDITION	CONTAINMENT	STABILISATION	RECOVERY
Normal	49.0 to 51.0 Hz		
Load and Generation event	48.0 to 52.0 Hz	49.0 to 51.0 Hz within 10 minutes	
Network event	48.0 to 52.0 Hz	49.0 to 51.0 Hz within 10 minutes	
Separation event	47.0 to 55 Hz	48.0 to 52.0 Hz within 2 minutes	49.0 to 51.0 Hz within 10 minutes
Multiple Contingency Event	47.0 to 55.0 Hz	48.0 to 52.0 Hz within 2 minutes	49.0 to 51.0 Hz within 10 minutes

Table 6: NEM Mainland Frequency Operating Standards – Rule Terms

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
TERM	NORMAL RANGE (HZ)	ISLAND RANGE (HZ)	RESTORATION RANGE (HZ)
Normal Operating Frequency Band	49.85 to 50.15	49.5 to 50.5	49.5 to 50.5
Normal Operating Frequency Excursion Band	49.75 to 50.25	49.5 to 50.5	49.5 to 50.5
Operational Frequency Tolerance Band	49.0 to 51.0	49.0 to 51.0	48.0 to 52.0
Extreme Frequency Excursion Tolerance Limit	47.0 to 52.0	47.0 to 52.0	47.0 to 55.0

Table 7: Tasmania Frequency Operating Standards – Rule Terms

TERM	NORMAL RANGE (HZ)	ISLAND RANGE (HZ)
Normal Operating Frequency Band	49.85 to 50.15	49.0 to 51.0
Normal Operating Frequency Excursion Band	47.5 to 50.25	49.0 to 51.0
Operational Frequency Tolerance Band	48.0 to 52.0	48.0 to 52.0
Extreme Frequency excursion tolerance Limit	47.0 to 55	47.0 to 55

4 Guidelines for Measuring the Time the Frequency was outside Normal Operating Band following a Load or Contingency Event

The frequency operating standards for both the mainland regions and the Tasmania region require that, during periods when there are no contingency events and no load events, the frequency be maintained within the range 49.85 to 50.15 Hz for 99% of the time, with larger deviations permitted within the range 49.75 to 50.25 Hz for no more than 1% of the time.

For an island within the mainland regions or an island within the Tasmania power system, the frequency operating standards require that, during periods when there are no contingency events and no load events, the frequencies be maintained within the ranges 49.5 to 50.5 Hz and 49.0 and 51.0 Hz respectively.

Occasions where Basslink is starting, stopping or reversing its power flow are considered as load events as defined in the Tasmania region frequency operating standards.

For the purpose of interpreting the frequency operating standards, the amount of time the frequency was outside normal operating band as a result of low or high frequency event is measured as described in the steps below:

1. Start measurement the first instance the frequency exceeds normal operating band.
2. Add up all the times the frequency was outside normal operating band (areas shaded in grey in Figures 1 and 2 below).
3. In the case of a load or contingency event, if the frequency is still outside the normal operating band when the load or contingency event has ceased, then stop measurement the first instance the frequency returns to within the normal operating band following the end of the load or contingency event. Otherwise, stop measurement the last instance the frequency returns to within the normal operating band prior to the end of the load or contingency event[6].

[6] A contingency event means an event affecting the power system which AEMO expects would be likely to involve the failure or removal from operational service of a generating unit or transmission element

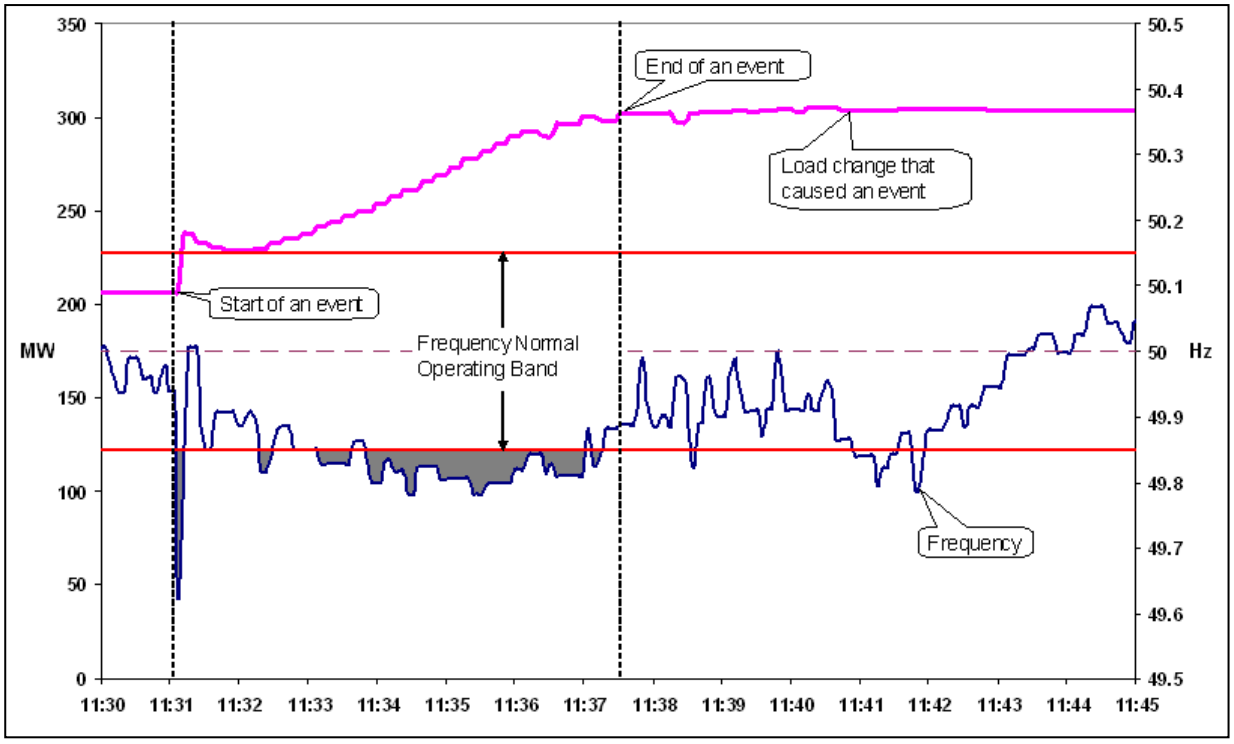

Figure 1: Example showing the time frequency was outside the normal operating band

The example in Figure 2 illustrates the nature of load events in Tasmania and how the measurement of time outside the normal operating band is not always straight forward. It also shows that for the event in this example, the standard requiring recovery to 49.85 Hz within a time of 300 seconds was not met.

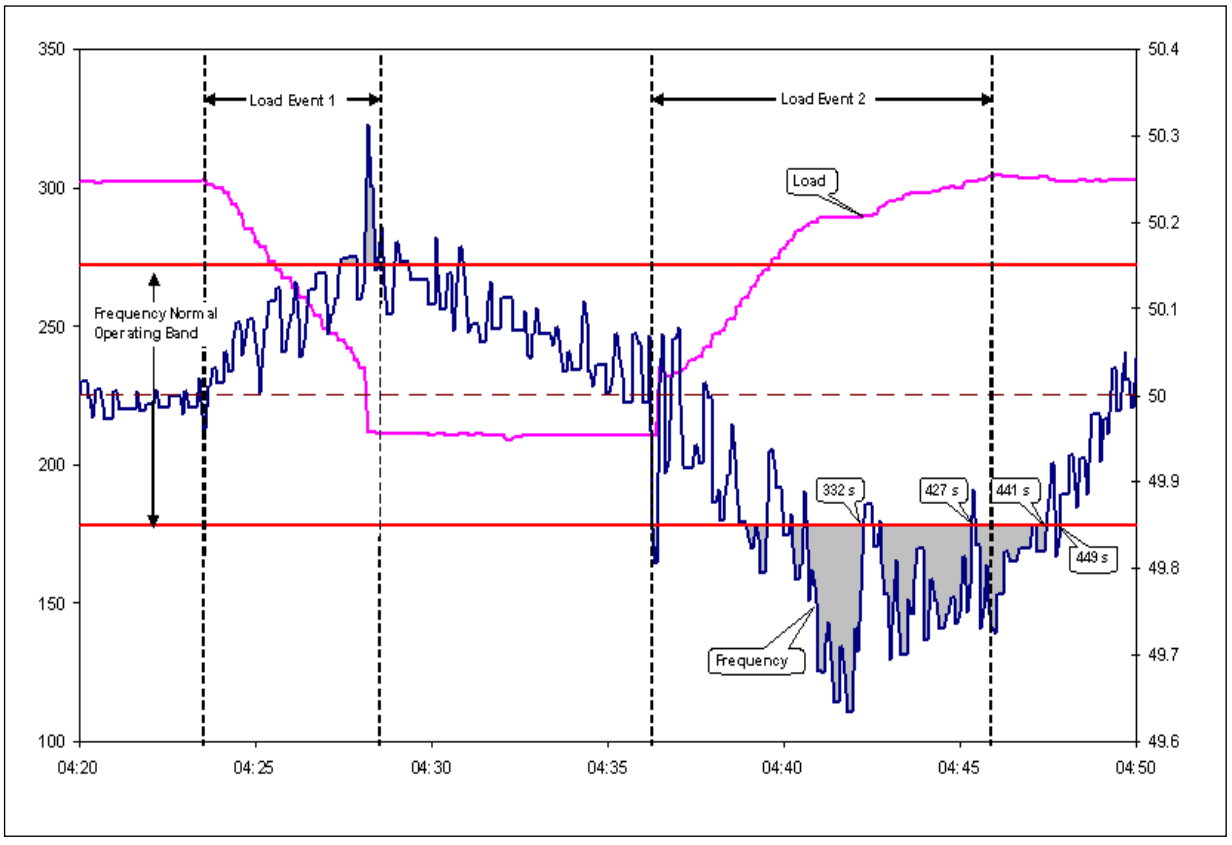

Figure 2: Example showing two consecutive load events, load reduction and load restoration and the times frequency was outside normal frequency operating band

Figure 2 illustrates the issues relating to controlling the frequency during such events. The load restoration commenced with a step increase and then gradually increased further over time. After the initial portion of load was restored the frequency immediately recovered to the pre-event level. However the gradual restoration of load continued over the longer period of time during which the frequency moved outside the normal operating frequency band. Figure 2 also illustrates that for some events, measuring the time the frequency was outside the normal operating frequency band is subjective and is left to interpretation to identify when the load event is complete. In Figure 2 there are number of times that could be selected as the event end time.

The guidelines applied by AEMO to the example in Figure 2 indicate a recovery time of 441 seconds.

Figure 2 also illustrates the issues relating to evaluating FCAS performance during such load events. During the second load event (load restoration) the frequency almost instantaneously recovered to 50 Hz which suggests that fast service was effective in arresting the frequency fall. However as the load continues to be restored the frequency begins to fall again. Evaluation of slow and delayed services for this particular example cannot be evaluated because FCAS evaluation does not continue beyond the first instance that the frequency returns to 49.9 Hz. This is further explained in section 5.

5 Guidelines Used for Verification of Market Ancillary Service Delivery

Plant trips cause frequency disturbances[7] due to the plant output changing rapidly. In addition, load or generation events can occur as a ramp rather than a step change, as has been observed in Tasmania. In both these cases verification of FCAS response is done consistent with the methodology described in the MASS. The FCAS assessment starts at the frequency disturbance time[8] and ends at the frequency recovery time[9]. Figures 3 and 4 below indicate the verification start and end for a generation trip and a gradual load ramp.

[7] An occasion when the *frequency* of the *power system* moves outside the *normal operating frequency band*
[8] 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.
[9] 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

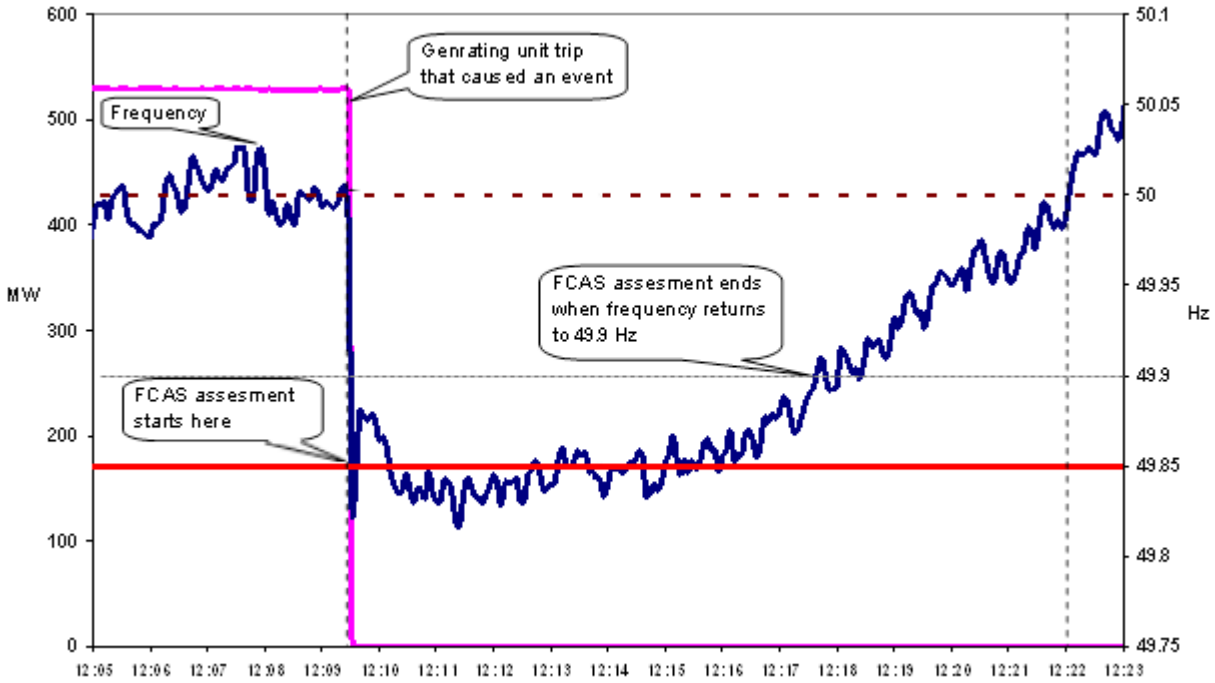

Figure 3: Example of an event where the frequency change is rapid

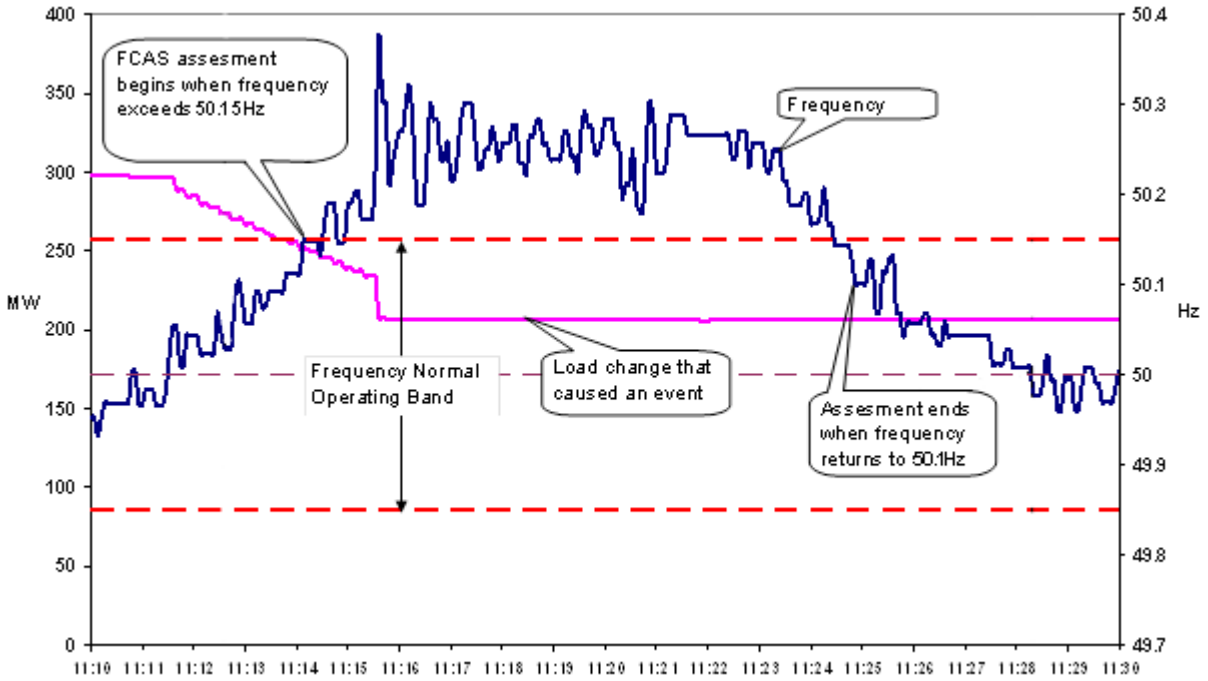

Figure 4: Example of an event in Tasmania where the frequency change is gradual

6 Changes to Regulating Raise and Regulating Lower Services Requirements for the NEM

6.1 Changes in regulating raise and regulating lower services requirements effective 17 December 2007.

AEMO has developed FCAS constraint equations in dispatch to determine the required amounts of regulating raise service and regulating lower service taking into account the power system time error. These constraint equations are now implemented following a trial that commenced on 17 December 2007.

6.2 Co-optimisation of regulating and delayed services.

From 1 January 2009, AEMO has introduced co-optimisation between regulating and delayed services.