POWER SYSTEM FREQUENCY AND TIME DEVIATION MONITORING

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1 Disclaimer

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2 Introduction

AEMO is required to maintain the power system frequency and time deviation within the limits specified in the frequency operating standards determined for the Mainland and the Tasmania Region by the Reliability Panel. This document reports on the frequency and time deviation performance observed during February 2012 in all regions of the NEM. Regions QLD, NSW, VIC and SA will be referred to as the Mainland regions throughout the report.

The frequency operating standards for the Mainland regions and the Tasmania region are available on the AEMC web site[1].

The "Power System Frequency and Time Deviation Monitoring Report – Reference Guidelines[2]" outlines the calculation processes used by AEMO in the preparation of the monthly Power System Frequency and Time Deviation Monitoring reports.

The analysis of the delivery of slow raise service, slow lower service, delayed raise service and delayed lower service presented in this report are based on 4-second resolution data. Data for Mainland regions is sourced from the Sydney PI server and data for Tasmania region is sourced from the Brisbane PI server. The analysis of fast raise service and fast lower service delivered is based on high-speed (50-millisecond or higher resolution) data and is only presented in this report for events where the appropriate data is available.

Table 1 below summarises events in the Mainland and Tasmanian regions for the month February 2012 with frequency excursions outside the normal operating frequency band. Any events in Table 1 that are identified with frequency excursions that did not meet the frequency operating standards are evaluated in section 4 of the report.

[1] 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
[2] The Power System Frequency and Time Deviation Monitoring Report – Reference Guide is available from http://www.aemo.com.au/Electricity/Market-and-Power-Systems/NEM-Reports/Power-System-Performance-Monitoring

3 Summary of Events

Table 1: Events in the Mainland and Tasmanian regions with frequency excursions outside the normal frequency operating band.

EVENT	LOW/HIGH FREQUENCY EVENT	NUMBER OF EVENTS	
		MAINLAND	TASMANIA
No contingency or load event/Normal event	LOW	0	73
	HIGH	1	28
Load Event	LOW	0	103
	HIGH	0	227
Generation Event	LOW	1	3
	HIGH	0	0
Network Event	LOW	1	1
	HIGH	0	0
Separation Event	LOW	0	0
	HIGH	0	0
Multiple Contingency Event	LOW	0	0
	HIGH	0	0

4 Events in the Mainland and Tasmania Regions that did not meet the Frequency Operating Standards

In this section, details are provided of those events identified in Table 1 as not meeting the frequency operating standard applicable to each event.

4.1 Frequency Events in Mainland Regions

There was one High Frequency No-Contingency Event from Table 1 recorded in Mainland during February 2012 that resulted in frequencies below 49.75 Hz. This event listed in Table 2 did not meet the Mainland Frequency Operating Standards.

Table 2: High Frequency No-Contingency Event in the Mainland region exceeded the Mainland Frequency Operating Standards.

DATE	EVENTS	MAX FREQUENCY (HZ)	TIME OUTSIDE NORMAL OPERATING BAND (49.85 HZ - 50.15 HZ)
4/02/2012 03:57:56	No condition causing the event was identified.	50.44	4

4.1.1 Event: 04/02/2012 03:57:56

For the Normal (Non-Contingency) high frequency event on 4th Feb 2012 in Mainland, Figure 1 shows that the Mainland region frequency exceeded the Mainland Frequency Operating Standards and was outside the normal operating band for 1.9 seconds. Two Mainland generating units ramped up suddenly 5 MW above their respective targets which contributed to the frequency excursion. The frequency excursion stabilized less than a 4seconds sample period (i.e. 1.9 seconds), due to which it did not trigger any Lower Slow or Lower Delayed FCAS during the event. However, the amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

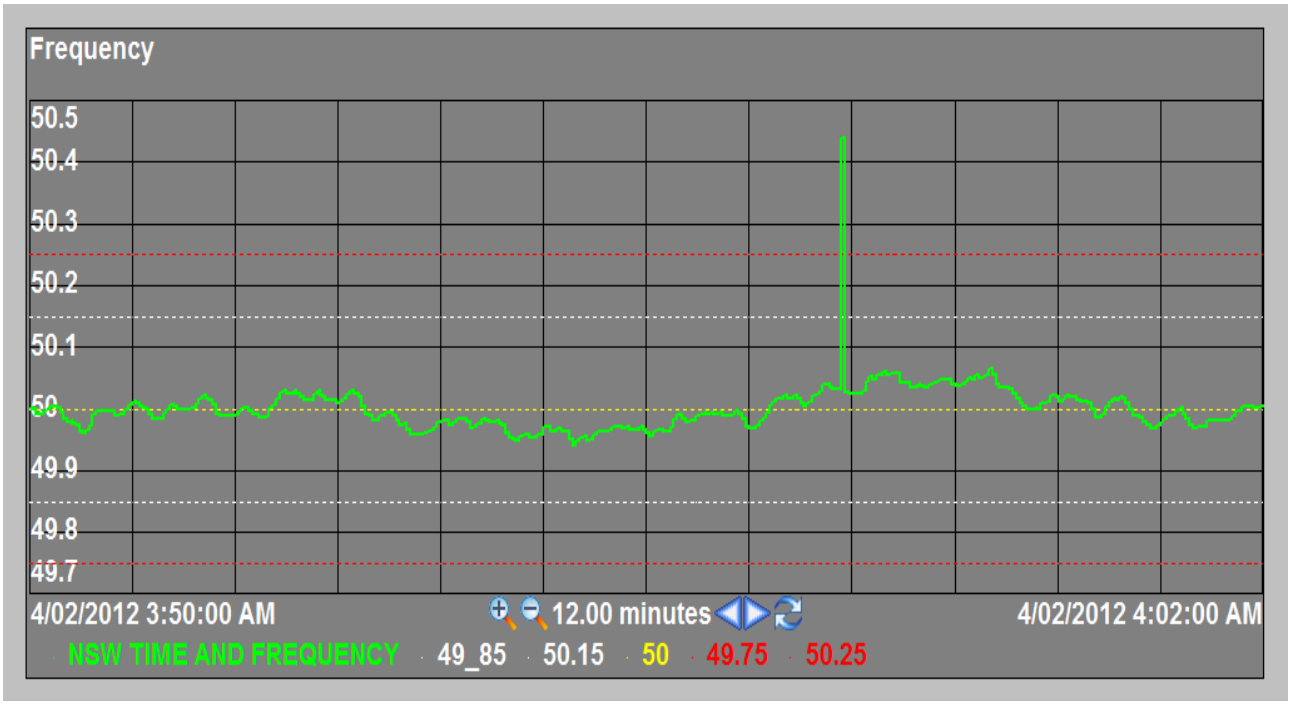

Figure 1: High Frequency No Contingency Event in Mainland refer to item 1 in Table 2 with the frequency exceeding the Mainland Frequency Operating Standard.

4.2 Low Frequency Events in Tasmania

There were eight Low Frequency Normal Condition Events from Table 1 recorded in Tasmanian during January 2012 that resulted in frequencies below 49.75 Hz. All of these events listed in Table 3 did not meet the Tasmania Frequency Operating Standards.

Table 3: Low Frequency Normal Events in the Tasmania region resulting in frequency outside the Tasmania Frequency Operating Standards

DATE	EVENTS	MIN FREQUENCY (HZ)	TIME OUTSIDE NORMAL OPERATING BAND (49.85 HZ - 50.15 HZ)
10/02/2012 04:24:00	No condition causing the event was identified.	49.74	124
12/02/2012 02:50:36	No condition causing the event was identified.	49.72	44
18/02/2012 07:36:20	No condition causing the event was identified.	49.67	20
19/02/2012 14:30:44	No condition causing the event was identified.	49.59	4
19/02/2012 15:30:40	No condition causing the event was identified.	49.54	4
21/02/2012 09:31:52	No condition causing the event was identified.	49.60	4
21/02/2012 16:00:36	No condition causing the event was identified.	49.59	16
22/02/2012 10:14:04	No condition causing the event was identified.	49.73	4

4.2.1 Event: 10/02/2012 04:24:00

For the Normal (Non-Contingency) low frequency event on 10th Feb 2012 in Tasmania, Figure 2 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 124 seconds. One Tasmanian generating unit ramped down approximately 50 MW below its respective generation target which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 3. The flow across Basslink was approximately 471 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller delivered about 10 MW of additional FCAS from Mainland to Tasmania during this event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.73 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

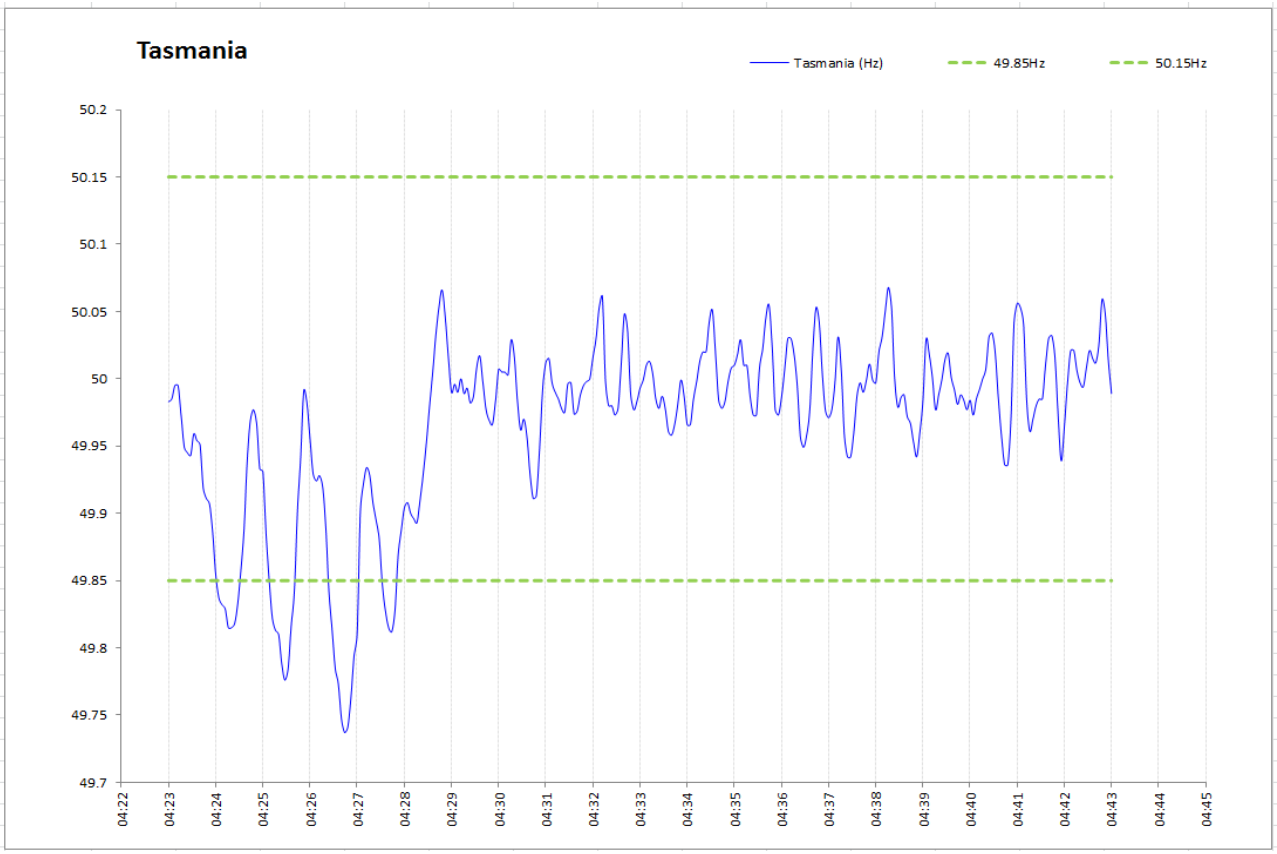

Figure 2: Low Frequency Normal Event in Tasmania refer to item 1 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

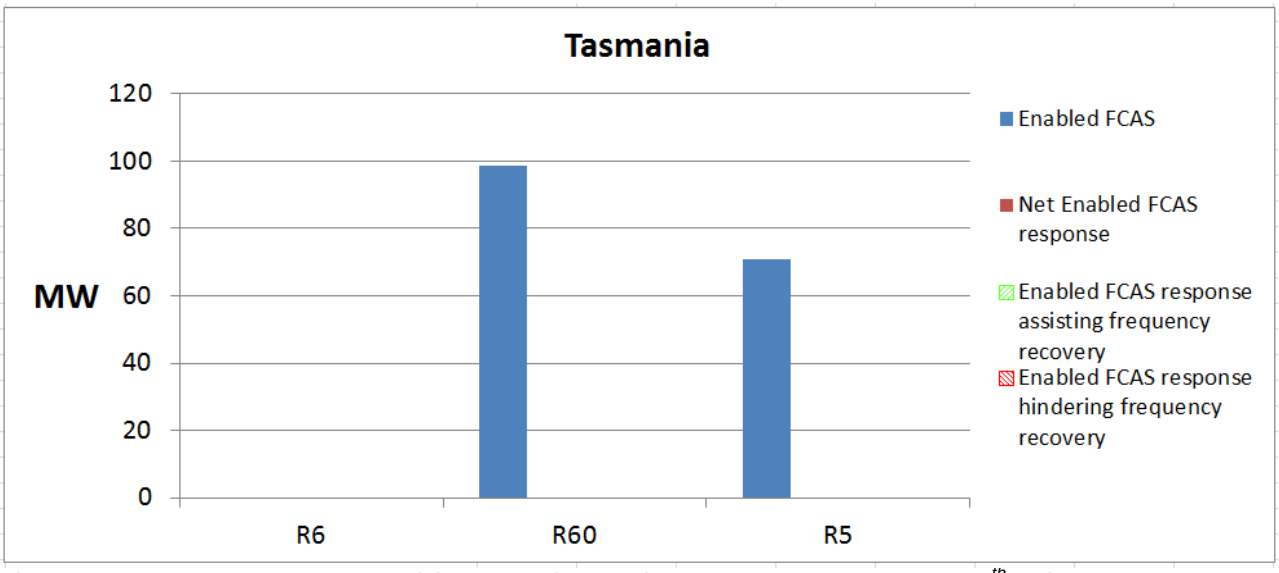

Figure 3: FCAS response to Normal (Non-Contingency) Low Frequency Event on 10th Feb 2012.

4.2.2 Event: 12/02/2012 02:50:36

For the Normal (Non-Contingency) low frequency event on 12th Feb 2012 in Tasmania, Figure 4 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 44 seconds. One Tasmanian generating unit ramped down approximately from 25 MW to zero MW, five minutes before its respective generation target which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 5. The flow across Basslink was approximately 453 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller delivered about 17 MW of additional FCAS from Mainland to Tasmania during this event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.72 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

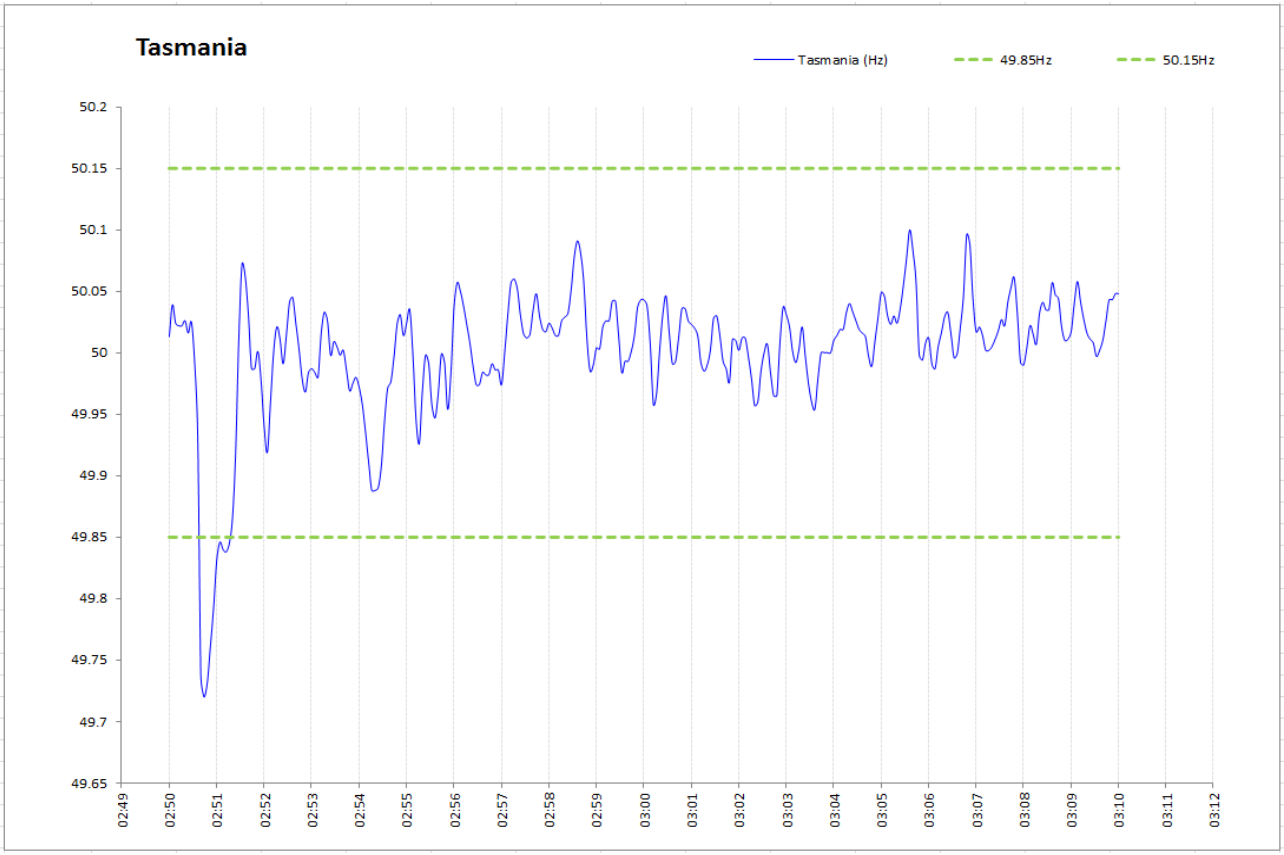

Figure 4: Low Frequency Normal Event in Tasmania refer to item 2 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

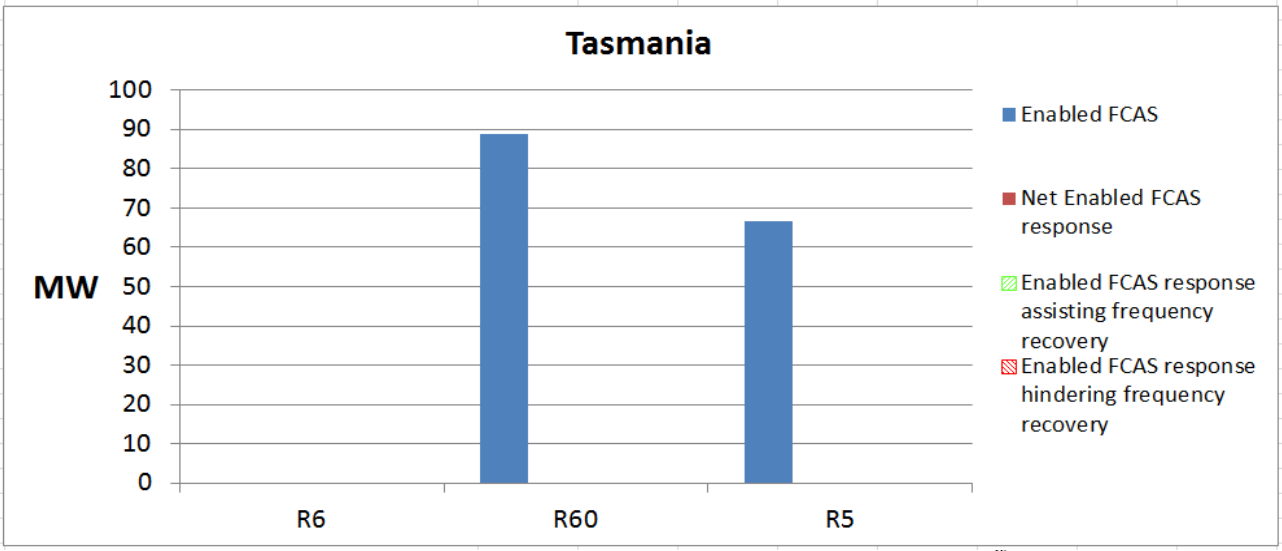

Figure 5: FCAS response to Normal (Non-Contingency) Low Frequency Event on 12tn Feb2012.

4.2.3 Event: 18/02/2012 07:36:20

For the Normal (Non-Contingency) low frequency event on 18th Feb 2012 in Tasmania, Figure 6 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 20 seconds. One Tasmanian generating unit ramped down below its respective generation target which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 7. The flow across Basslink was approximately 473 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller did not deliver any further FCAS from Mainland to Tasmania during this event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.66 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

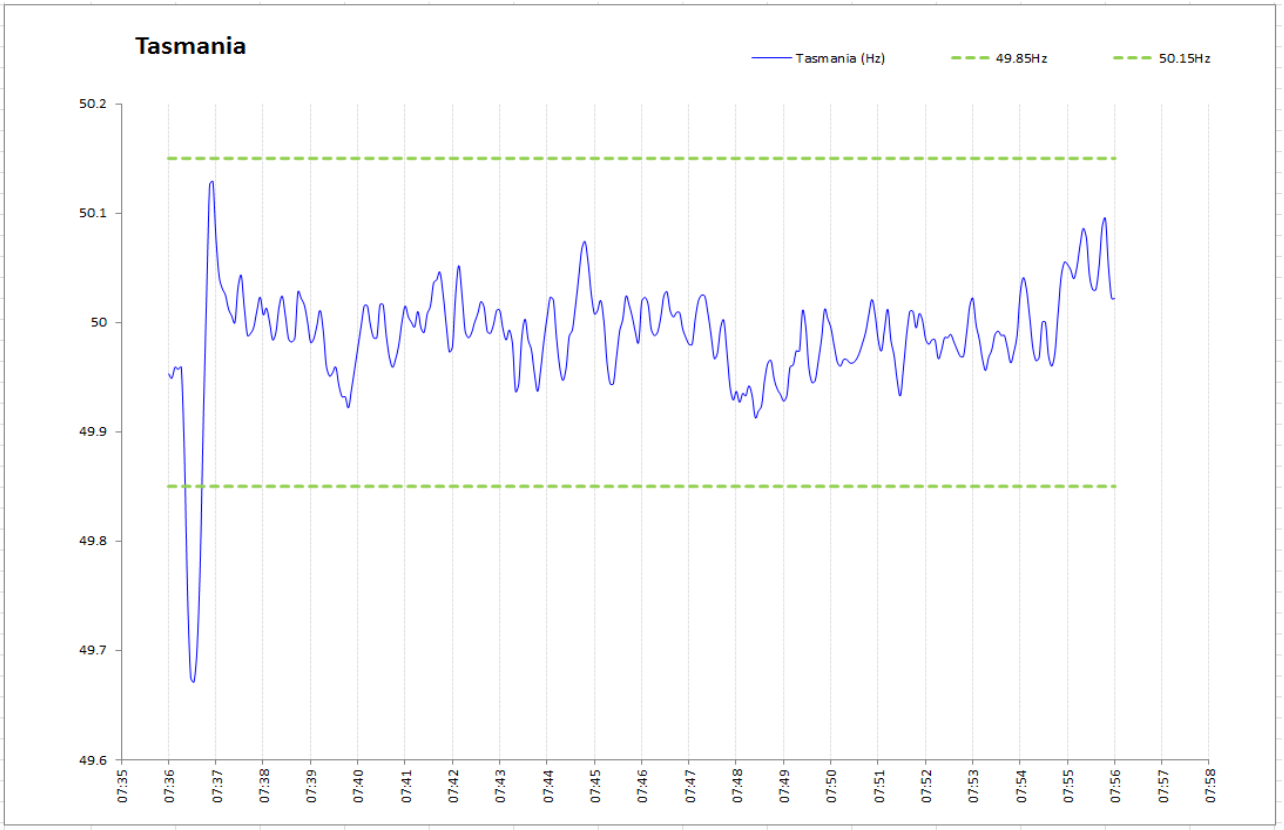

Figure 6: Low Frequency Normal Event in Tasmania refer to item 3 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

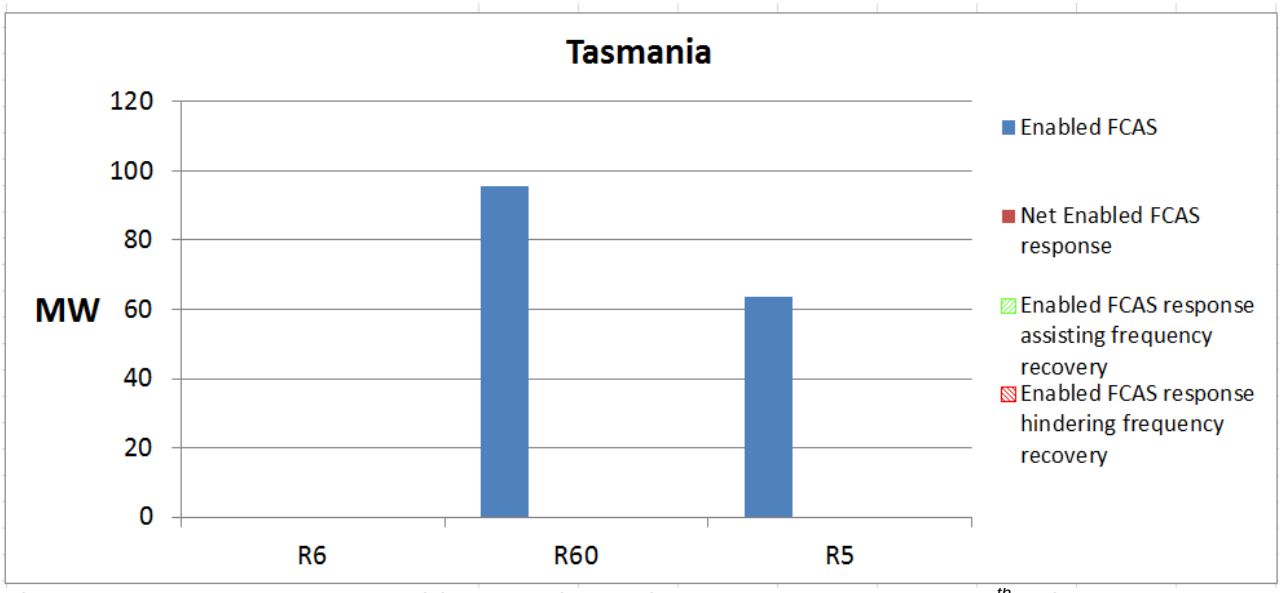

Figure 7: FCAS response to Normal (Non-Contingency) Low Frequency Event on 18th Feb2012.

4.2.4 Event: 19/02/2012 14:30:44

For the Normal (Non-Contingency) low frequency event on 19th Feb 2012 in Tasmania, Figure 8 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 4 seconds. Two Tasmanian generating units did not ramp up from zero MW following their respective generation targets from start-up, which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 9. The flow across Basslink was approximately 172 MW towards Mainland during the time of the frequency excursion. Basslink frequency controller delivered about 76 MW of additional FCAS from Mainland to Tasmania during this event by dropping the Tasmania export to Mainland from 172 MW to 96 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.58 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

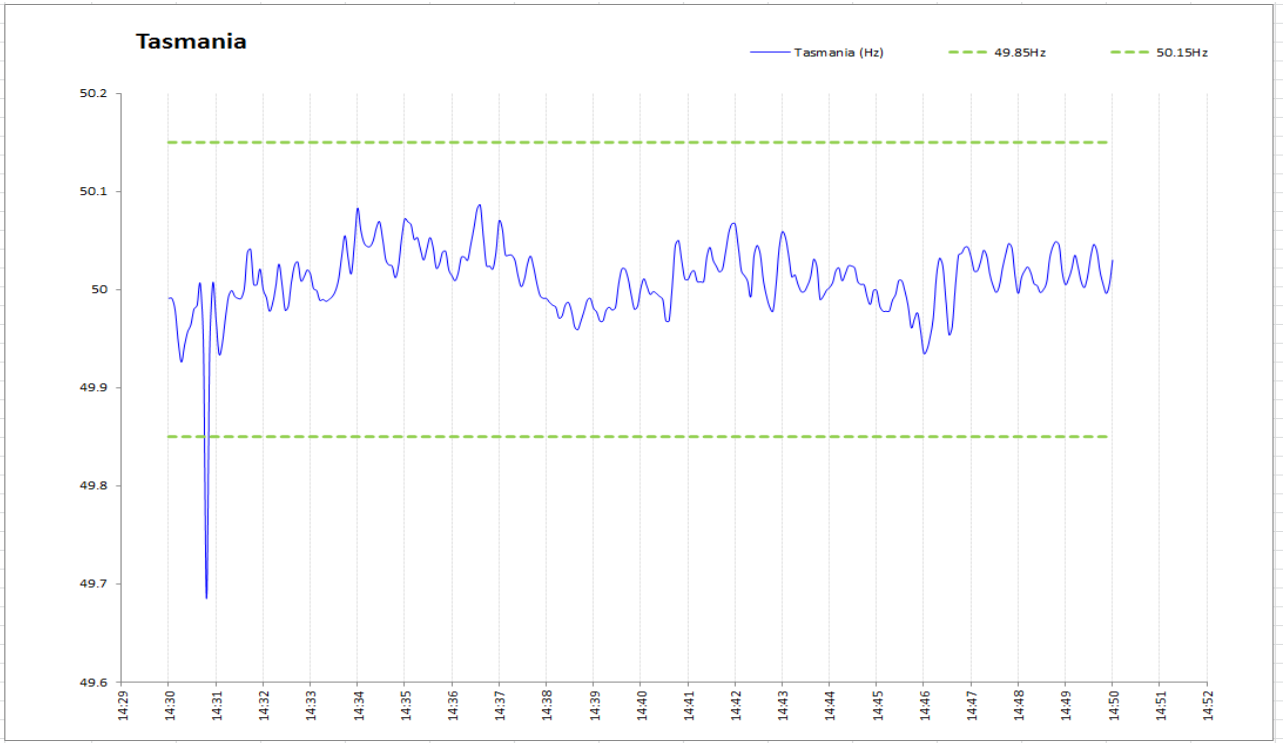

Figure 8: Low Frequency Normal Event in Tasmania refer to item 4 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

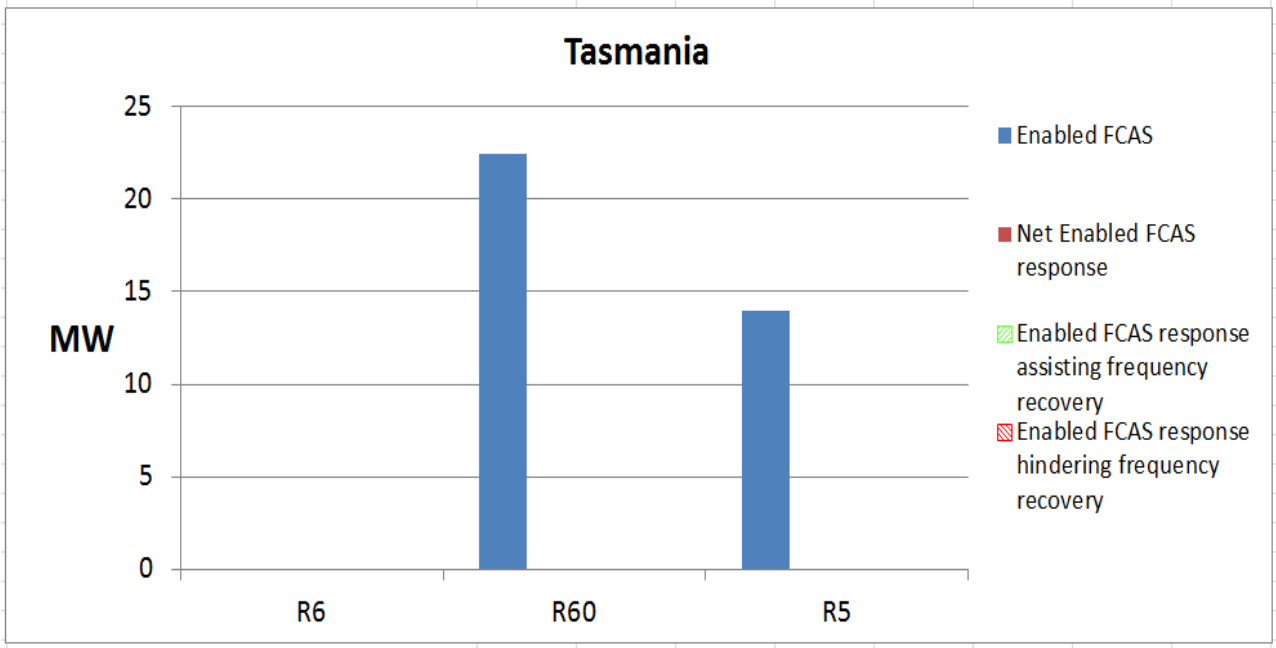

Figure 9: FCAS response to Normal (Non-Contingency) Low Frequency Event on 19th Feb 2012.

4.2.5 Event: 19/02/2012 15:30:40

For the Normal (Non-Contingency) low frequency event on 19th Feb 2012 in Tasmania, Figure 10 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 4 seconds. The sudden decrease in Tasmanian total load demand by 95 MW ~ 105 MW contributed to the frequency excursion although Tasmanian generation also decreased in response to the total demand. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 11. The flow across Basslink was approximately 203 MW towards Mainland during the time of the frequency excursion. Basslink frequency controller delivered about 97 MW of additional FCAS during this event by dropping the Tasmania export to Mainland from 203 MW to 106 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.54 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

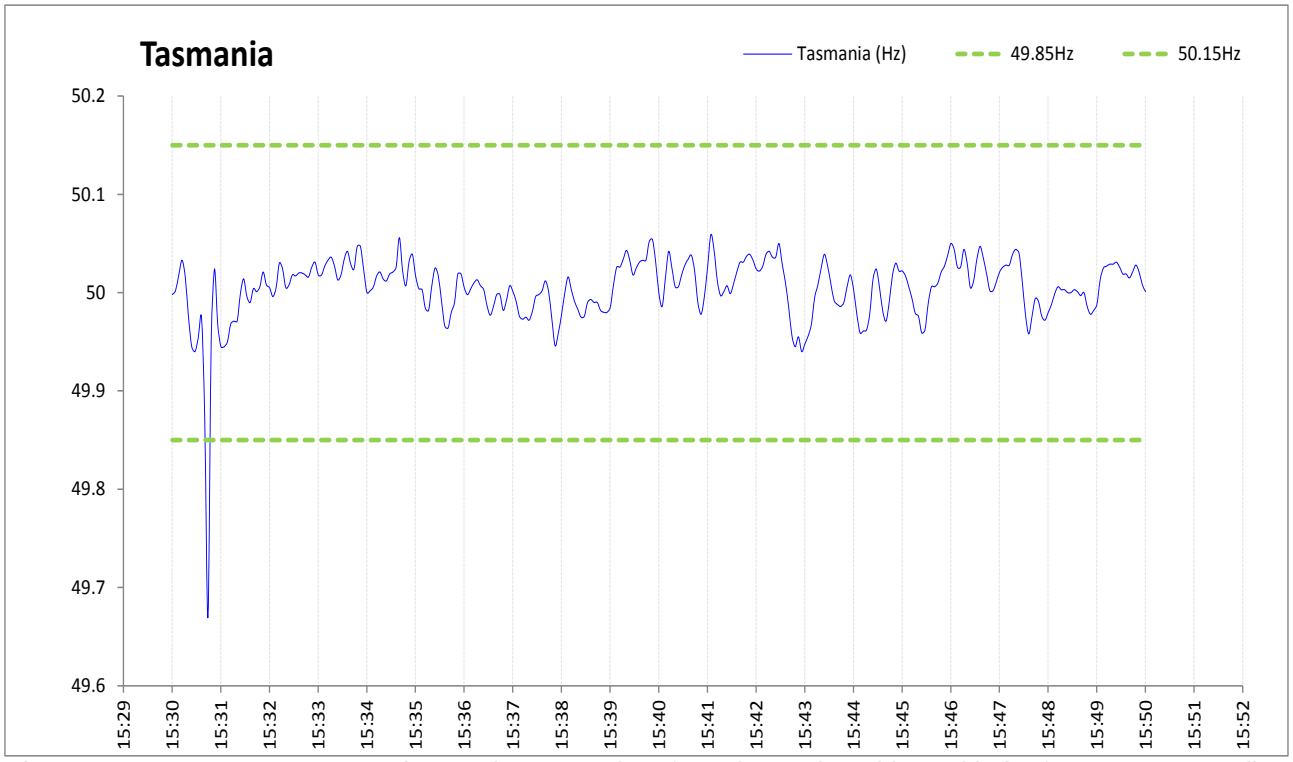

Figure 10: Low Frequency Normal Event in Tasmania refer to item 5 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

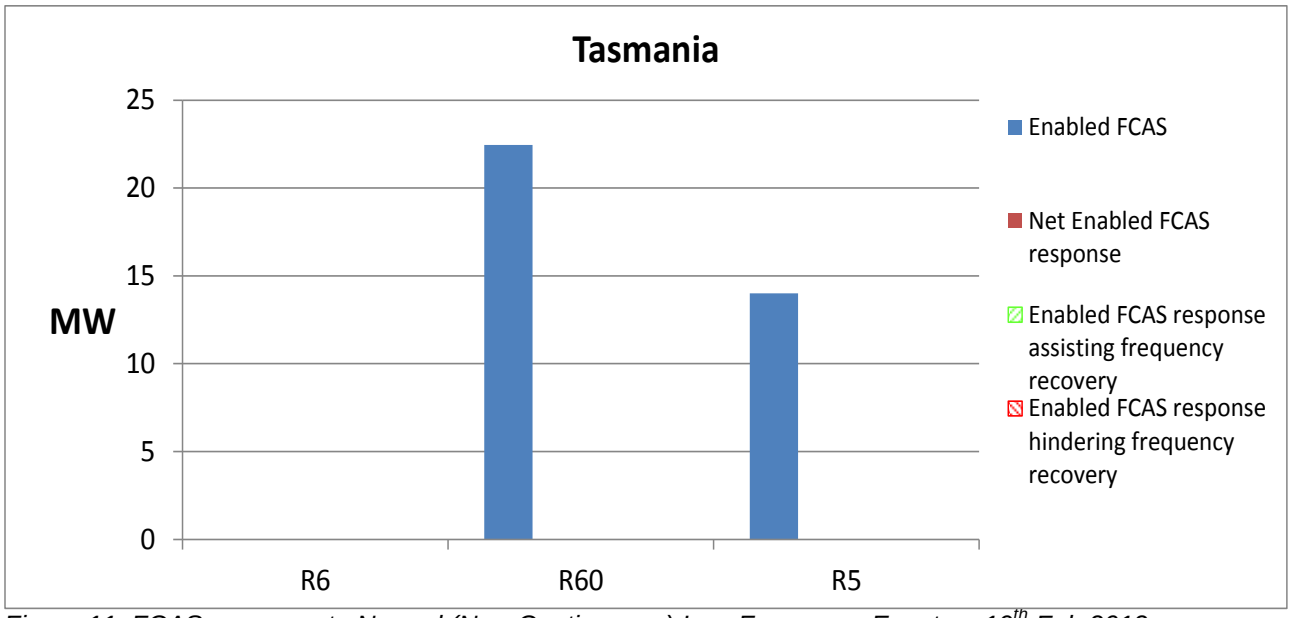

Figure 11: FCAS response to Normal (Non-Contingency) Low Frequency Event on 19th Feb 2012.

4.2.6 Event: 21/02/2012 09:31:52

For the Normal (Non-Contingency) low frequency event on 21st Feb 2012 in Tasmania, Figure 12 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 4 seconds. The sudden decrease in Tasmanian total load demand by 95 MW ~ 105 MW contributed to the frequency excursion although Tasmanian generation also decreased in response to the total demand. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 13. The flow across Basslink was approximately 176 MW towards Mainland during the time of the frequency excursion. Basslink frequency controller delivered about 89 MW of additional FCAS from Mainland to Tasmania during this event by dropping the Tasmania export to Mainland from 176 MW to 89 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.60 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

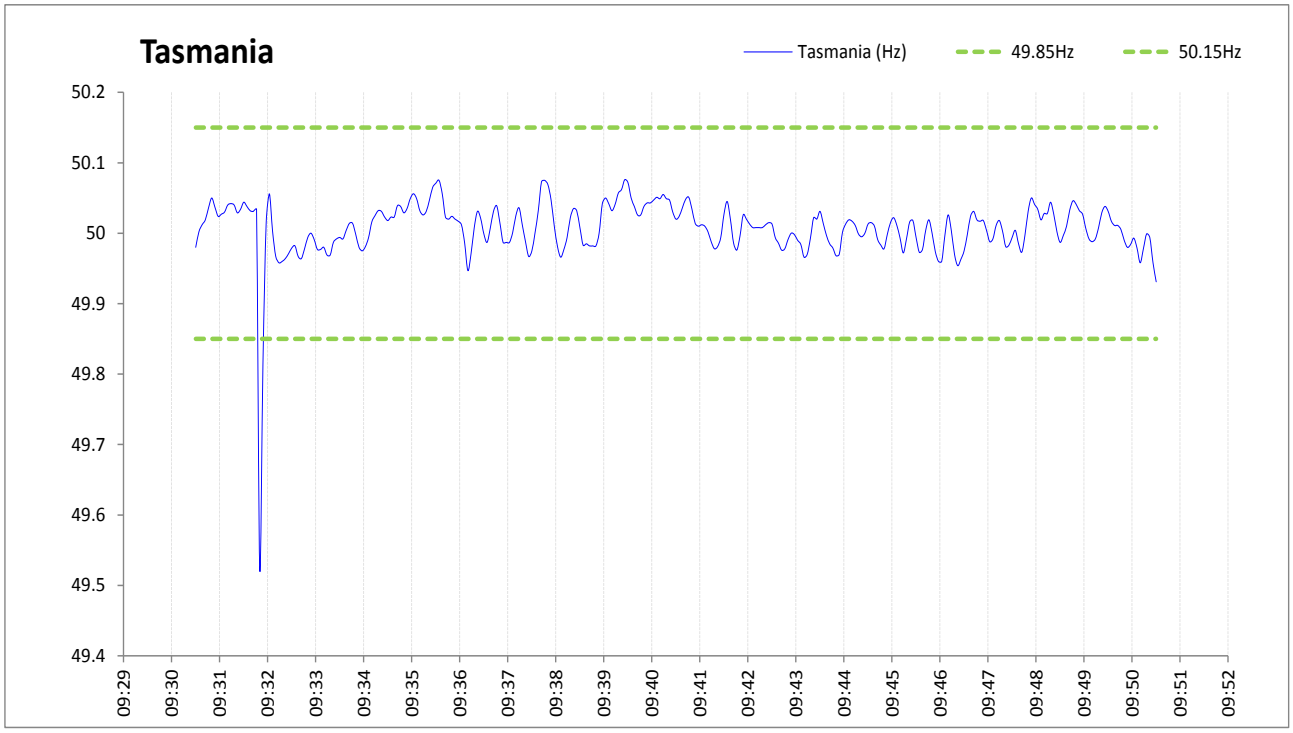

Figure 12: Low Frequency Normal Event in Tasmania refer to item 6 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

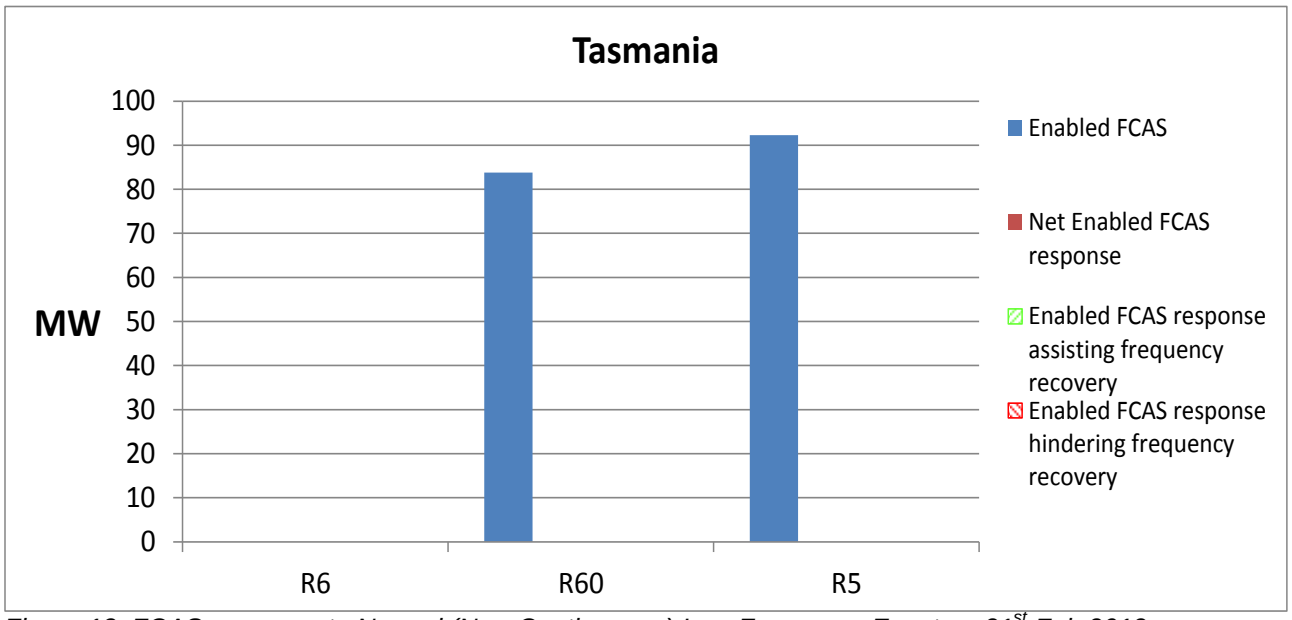

Figure 13: FCAS response to Normal (Non-Contingency) Low Frequency Event on 21st Feb 2012.

4.2.7 Event: 21/02/2012 16:00:36

For the Normal (Non-Contingency) low frequency event on 21st Feb 2012 in Tasmania, Figure 14 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 16 seconds. The sudden decrease in Tasmanian total load demand by 95 MW ~ 105 MW contributed to the frequency excursion although Tasmanian generation also decreased in response to the total demand. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 15. The flow across Basslink was approximately 151 MW towards Mainland during the time of the frequency excursion. Basslink frequency controller delivered about 105 MW of additional FCAS from Mainland to Tasmania during this event by dropping the Tasmania export to Mainland from 151 MW to 46 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.59 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

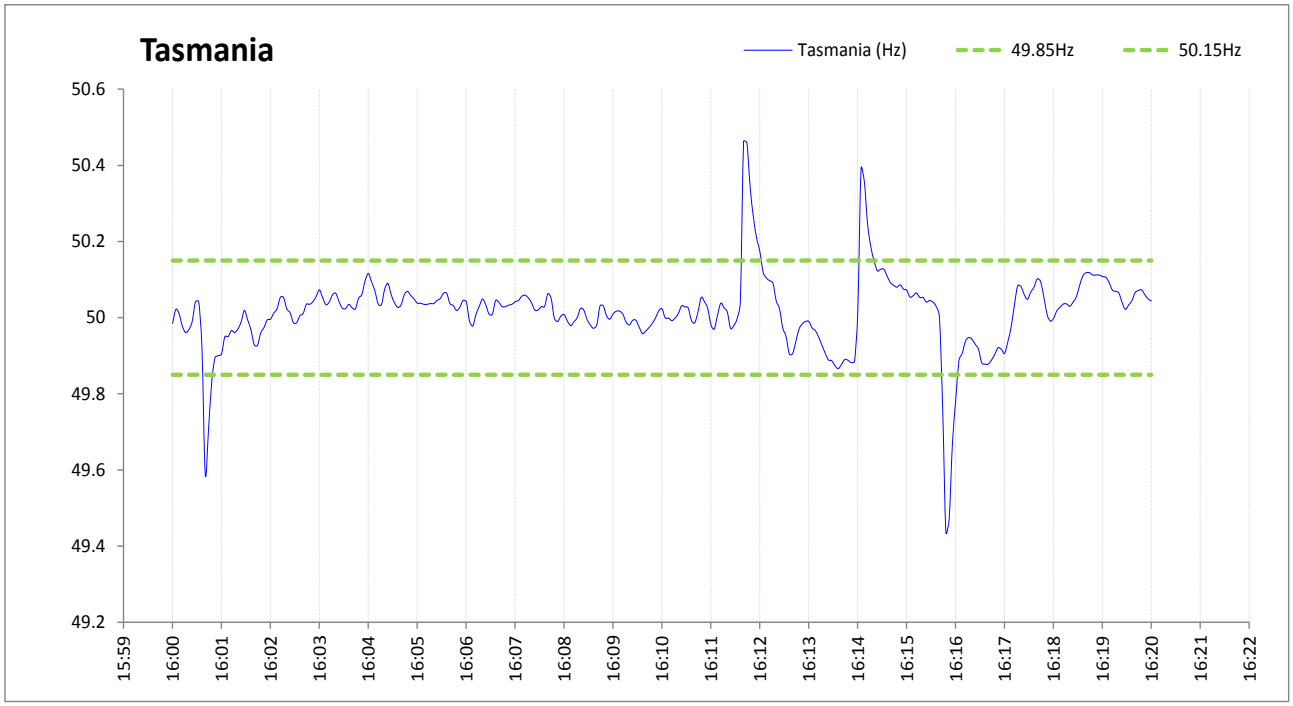

Figure 14: Low Frequency Normal Event in Tasmania refer to item 7 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

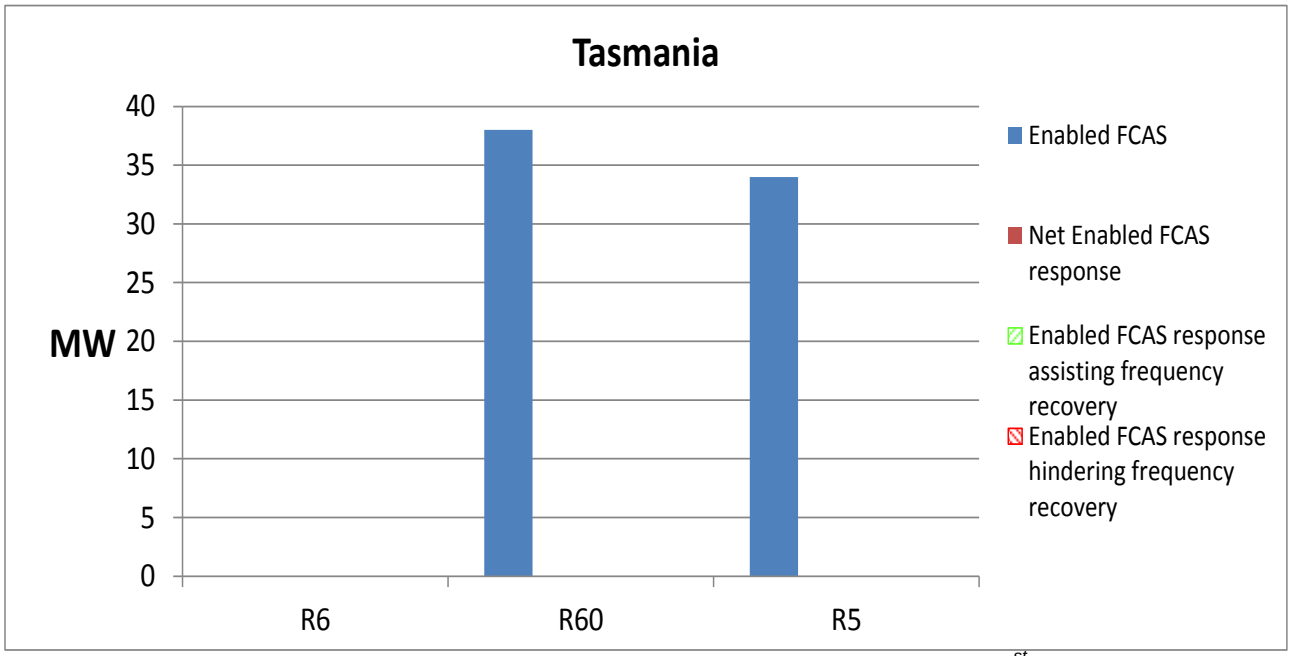

Figure 15: FCAS response to Normal (Non-Contingency) Low Frequency Event on 21st Feb 2012.

4.2.8 Event: 22/02/2012 10:14:04

For the Normal (Non-Contingency) low frequency event on 22nd Feb 2012 in Tasmania, Figure 16 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 4 seconds. One Tasmanian generating unit ramped up too slowly to their respective generation targets from start-up which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 17. The flow across Basslink was approximately 115 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller delivered about 34 MW of additional FCAS from Mainland to Tasmania during this event by increasing the Tasmania import to Mainland from 115 MW to 149 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.73 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

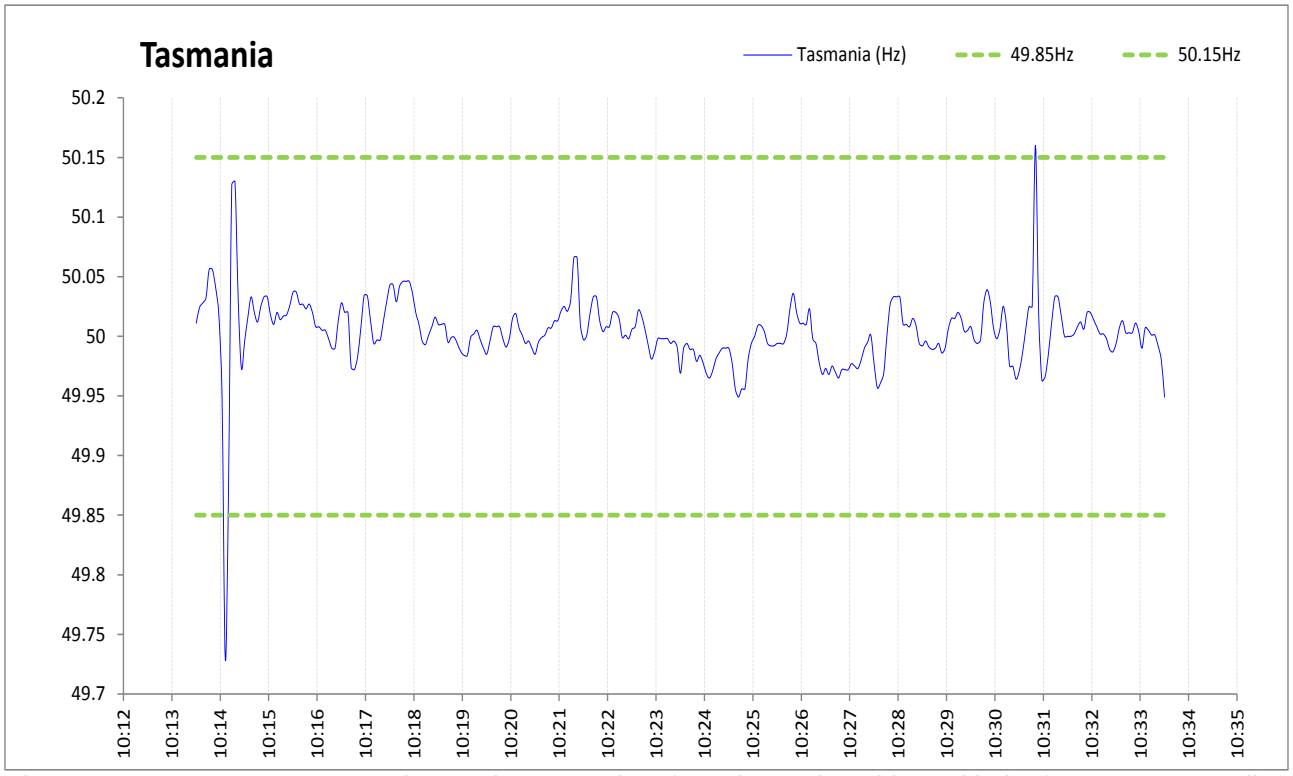

Figure 16: Low Frequency Normal Event in Tasmania refer to item 8 in Table 3 with the frequency exceeding the Tasmania Frequency Operating Standard.

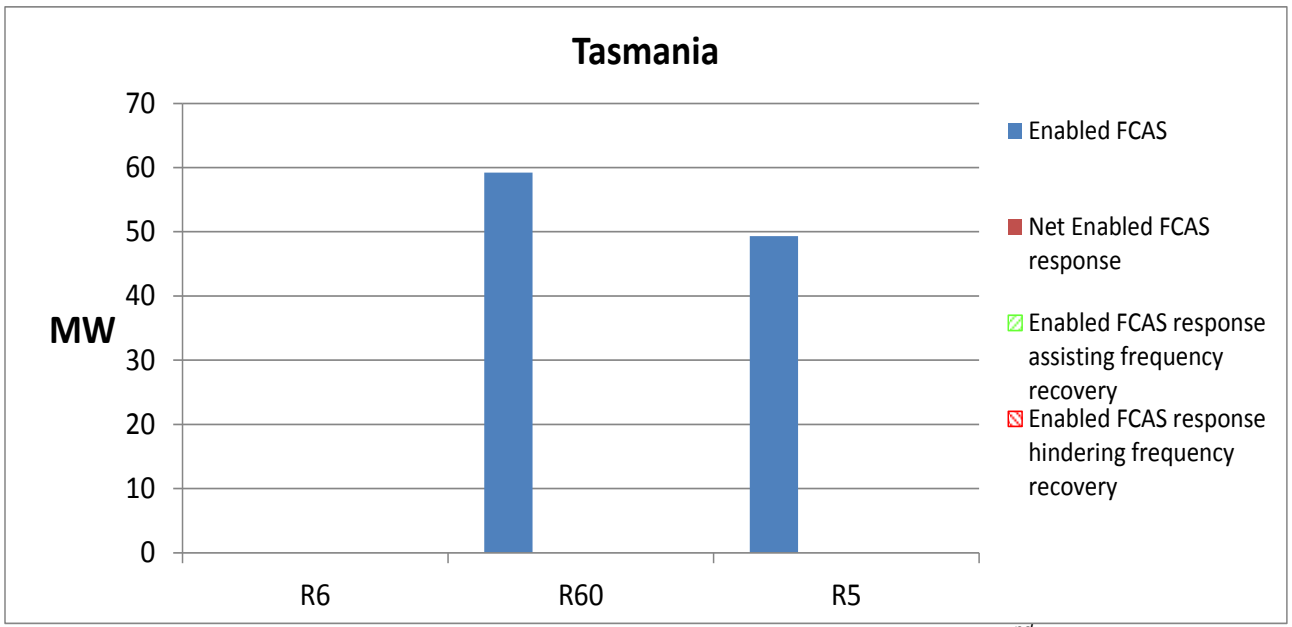

Figure 17: FCAS response to Normal (Non-Contingency) Low Frequency Event on 22nd Feb 2012.

4.3 High Frequency Events in Tasmania

There were two High Frequency Normal Condition Events from Table 1 recorded in Tasmanian region during February 2012 that resulted in frequencies above 50.25 Hz. All of these events listed in Table 4 did not meet the Tasmania Frequency Operating Standards.

Table 4: High Frequency Normal Events in the Tasmania region exceeded the Tasmania Frequency Operating Standards.

DATE	EVENTS	MIN FREQUENCY (HZ)	TIME OUTSIDE NORMAL OPERATING BAND (49.85 HZ - 50.15 HZ)
19/02/2012 15:01:04	No condition causing the event was identified.	50.33	24
19/02/2012 16:00:40	No condition causing the event was identified.	50.36	20

4.3.1 Event: 19/02/2012 15:01:04

For the Normal (Non-Contingency) high frequency event on 19th Feb 2012 in Tasmania, Figure 18 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 24 seconds. The sudden increase in Tasmanian total load demand by 60 MW ~ 70 MW contributed to the frequency excursion although Tasmanian generation also increased in response to the total demand. Three Tasmanian generating units ramped down too slowly to their respective generation targets which contributed to the frequency excursion. Compared to the enabled delayed raise FCAS, a zero amount was delivered as shown in Figure 19. The flow across Basslink was approximately 149 MW towards Mainland during the time of the frequency excursion. Basslink frequency controller delivered about 65 MW of additional FCAS during this event by increasing the Tasmania export to Mainland from 149 MW to 214 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency peaked to a maximum of 50.33 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

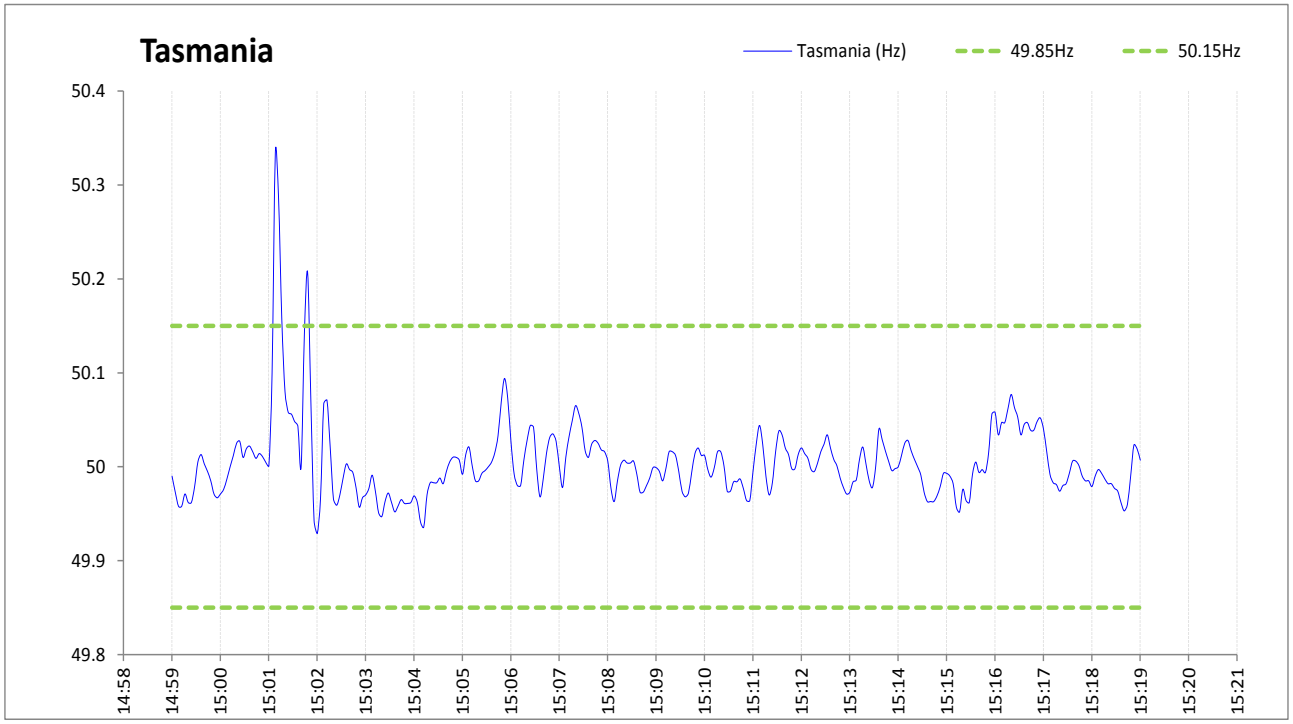

Figure 18: High Frequency Normal Event in Tasmania refer to item 1 in Table 4 with the frequency exceeding the Tasmania Frequency Operating Standard.

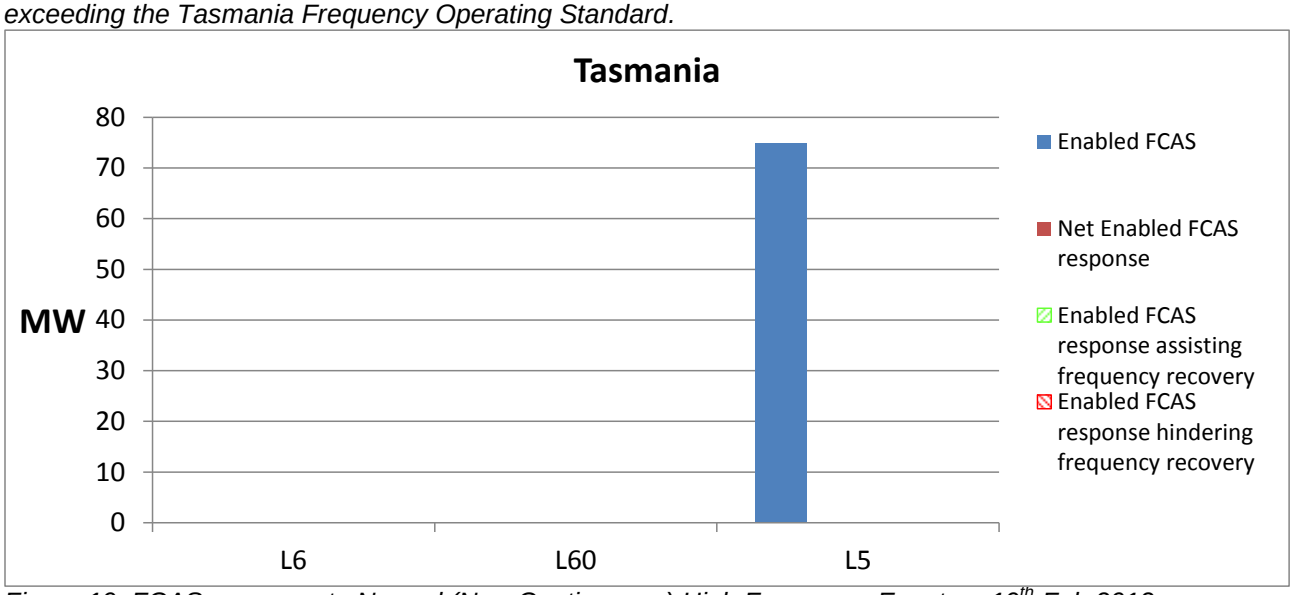

Figure 19: FCAS response to Normal (Non-Contingency) High Frequency Event on 19th Feb 2012.

4.3.2 Event: 19/02/2012 16:00:40

For the Normal (Non-Contingency) high frequency event on 19th Feb 2012 in Tasmania, Figure 20 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 20 seconds. The sudden increase in Tasmanian total load demand by 75 MW ~ 85 MW contributed to the frequency excursion although Tasmanian generation also increased in response to the total demand. Compared to the enabled delayed raise FCAS, a zero amount was delivered as shown in Figure 21. The flow across Basslink was approximately 173 MW towards Mainland during the time of the frequency excursion. Basslink frequency controller delivered about 55 MW of additional FCAS from Tasmania to Mainland during this event by increasing the Tasmania export to Mainland from 173 MW to 228 MW. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency peaked to a maximum of 50.36 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

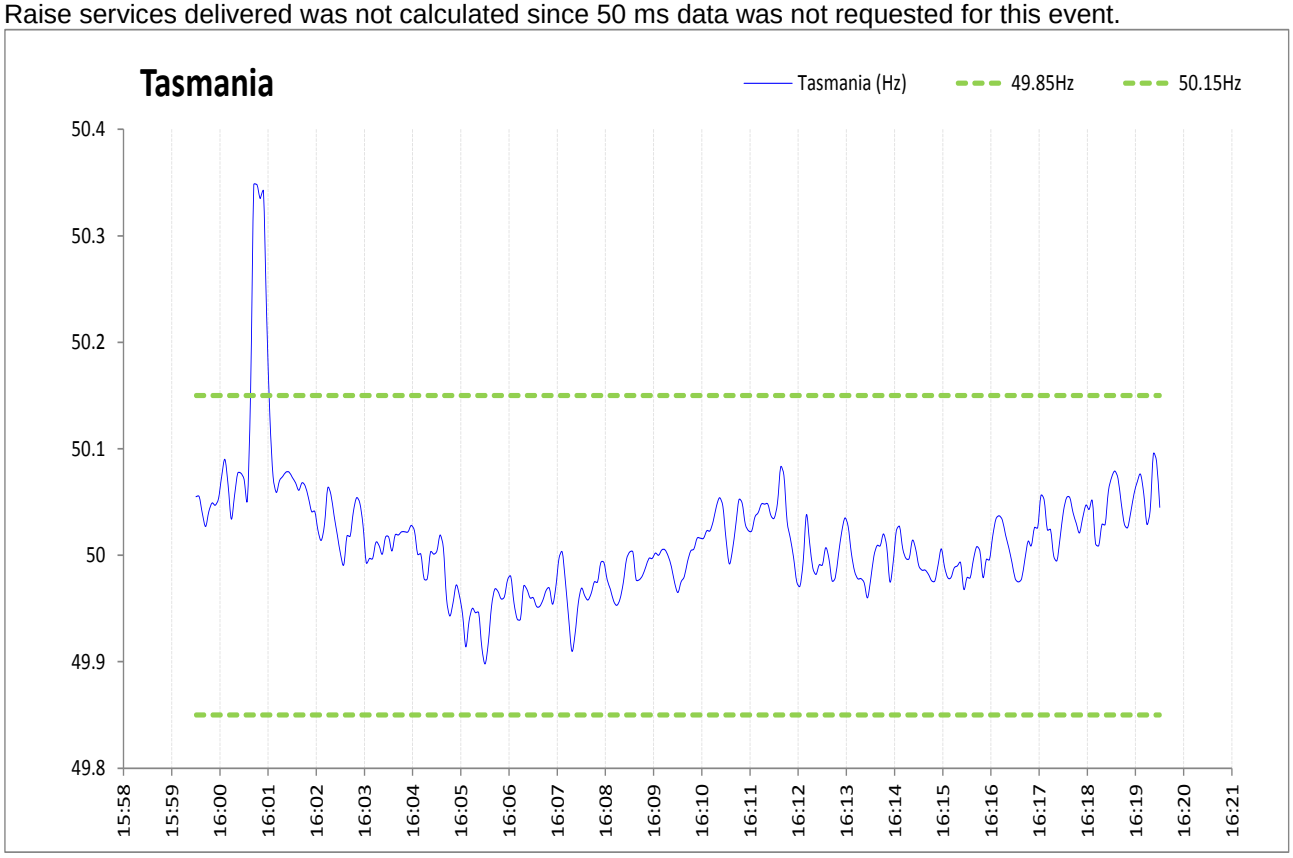

Figure 20: High Frequency Normal Event in Tasmania refer to item 2 in Table 4 with the frequency exceeding the Tasmania Frequency Operating Standard.

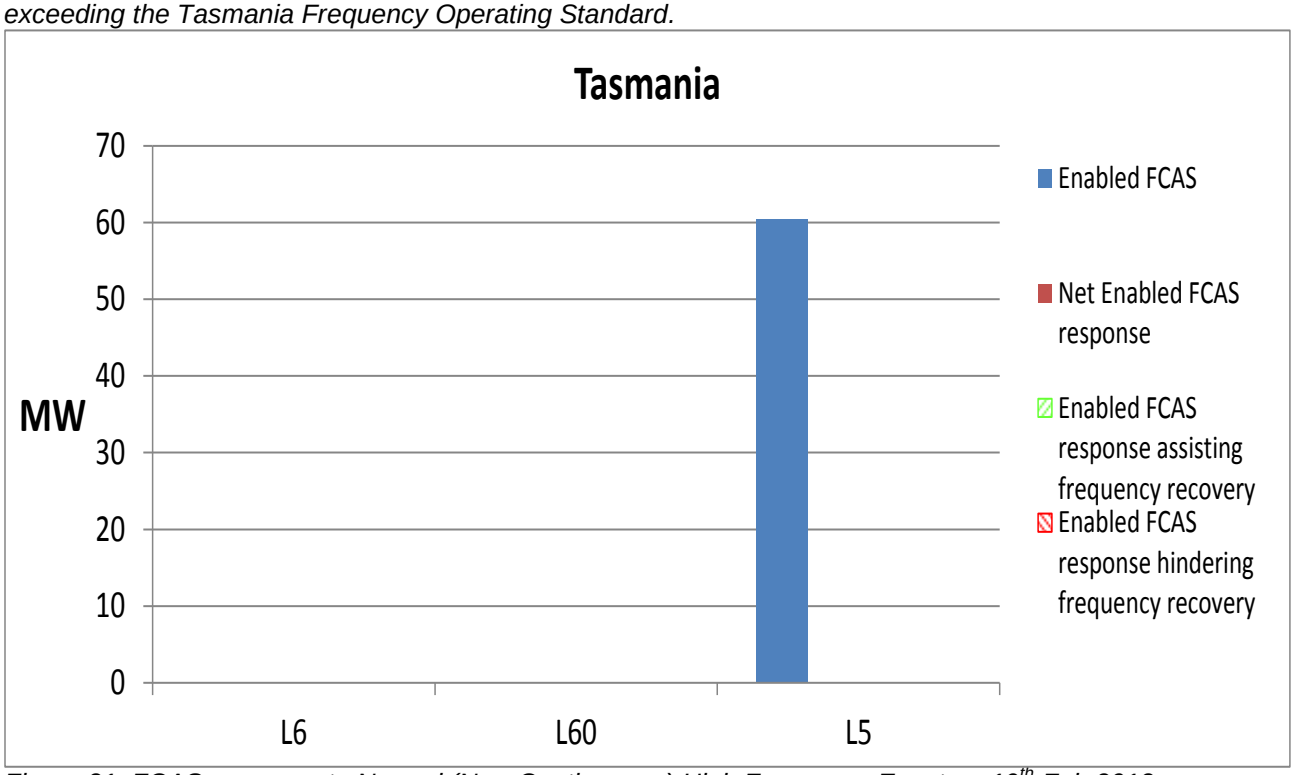

Figure 21: FCAS response to Normal (Non-Contingency) High Frequency Event on 19th Feb 2012.

5 Statistical analysis

With exception of load, generation, network, separation and multiple contingency events which are excluded, the frequency distribution for the Mainland and Tasmanian regions were within the frequency operating standards in the month of February 2012.

Frequency in the Mainland regions was within the range 49.92 to 50.07 Hz for 99% of the time. The frequency was within the range 49.75 Hz – 50.25 Hz for 100% of the time. The mean value of frequency during February 2012 was 50 Hz with a standard deviation of 0.028 Hz.

Frequency in the Tasmania region was within the range 49.90 – 50.9 Hz for 99% of the time. The frequency was within the range 49.75 Hz – 50.25 Hz for 99.98 % of the time. The mean value of frequency during February 2012 was 50 Hz with a standard deviation of 0.040 Hz.

5.1.1 Daily Frequency Standard Deviation

Error! Reference source not found. Figure 22 and Figure 23 below plot the daily standard deviation of the Mainland and Tasmanian frequency for the past 13 months, and do not exclude contingency events.

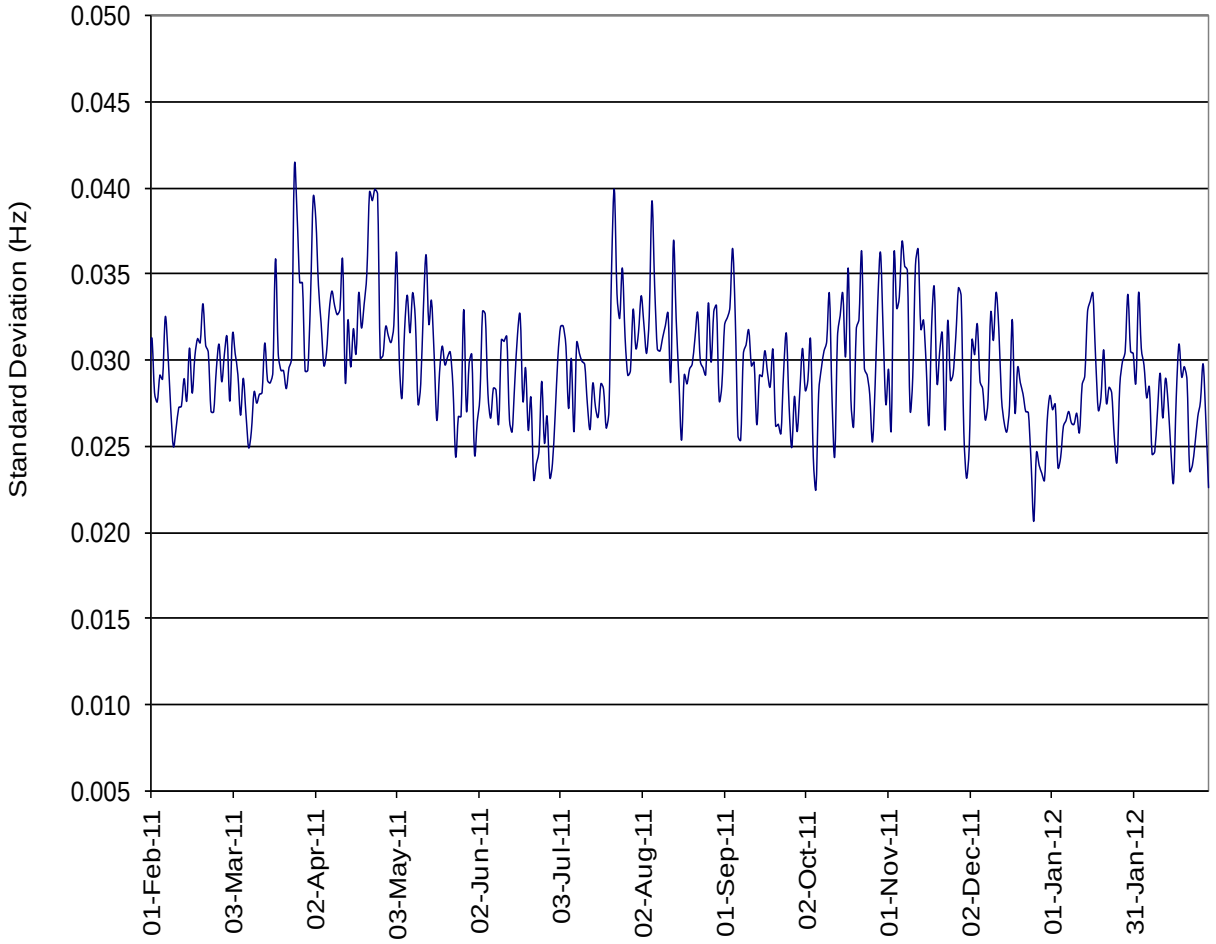

Figure 22: Daily standard deviation of Mainland frequency.

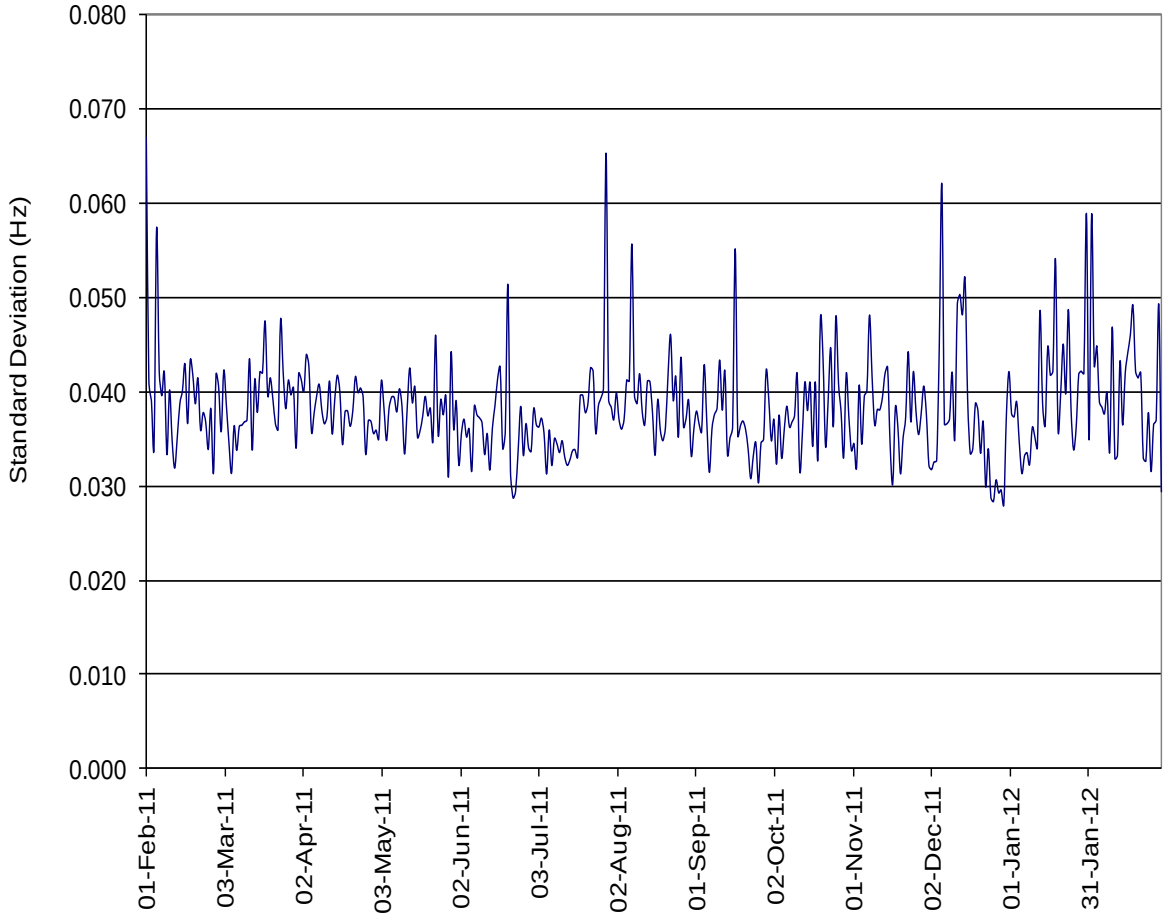

Figure23: Daily standard deviation of frequency in Tasmania.

5.1.2 Time of day Analysis

This section details the standard deviation of system frequency on a monthly and daily basis. Figure 24 and Figure 25 show the average half-hourly standard deviation of the Mainland regions and Tasmania frequency for December 2011, January and February 2012. The effects of contingency events have not been filtered from this time of day analysis.

The theoretical limit of 0.049 Hz shown in Figure 24 and Figure 25 would ensure that 99% of observed values were in the range 49.85 - 50.15 Hz with a very small probability of being less than 49.75 Hz and greater than 50.25 Hz. (This assumes that the frequency distribution follows an ideal normal distribution).

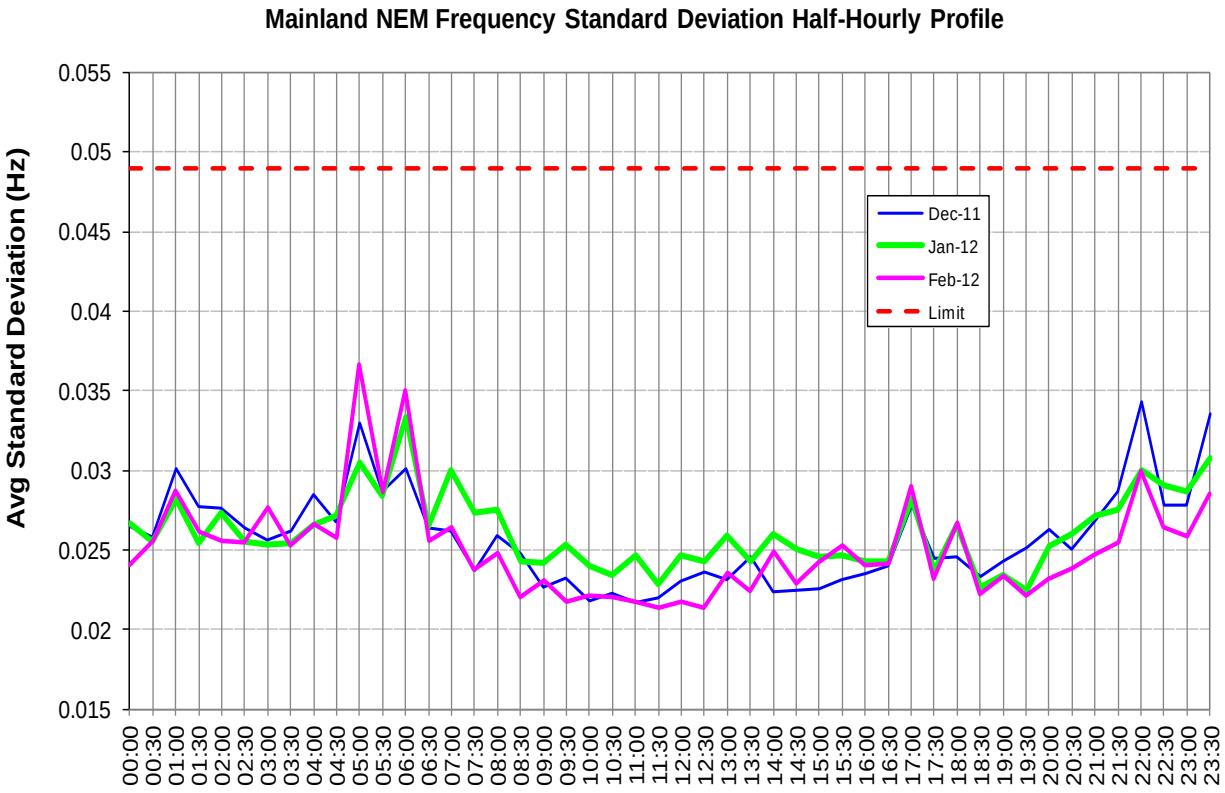

Figure 24: Daily profile of standard deviation for the frequency in the Mainland regions.

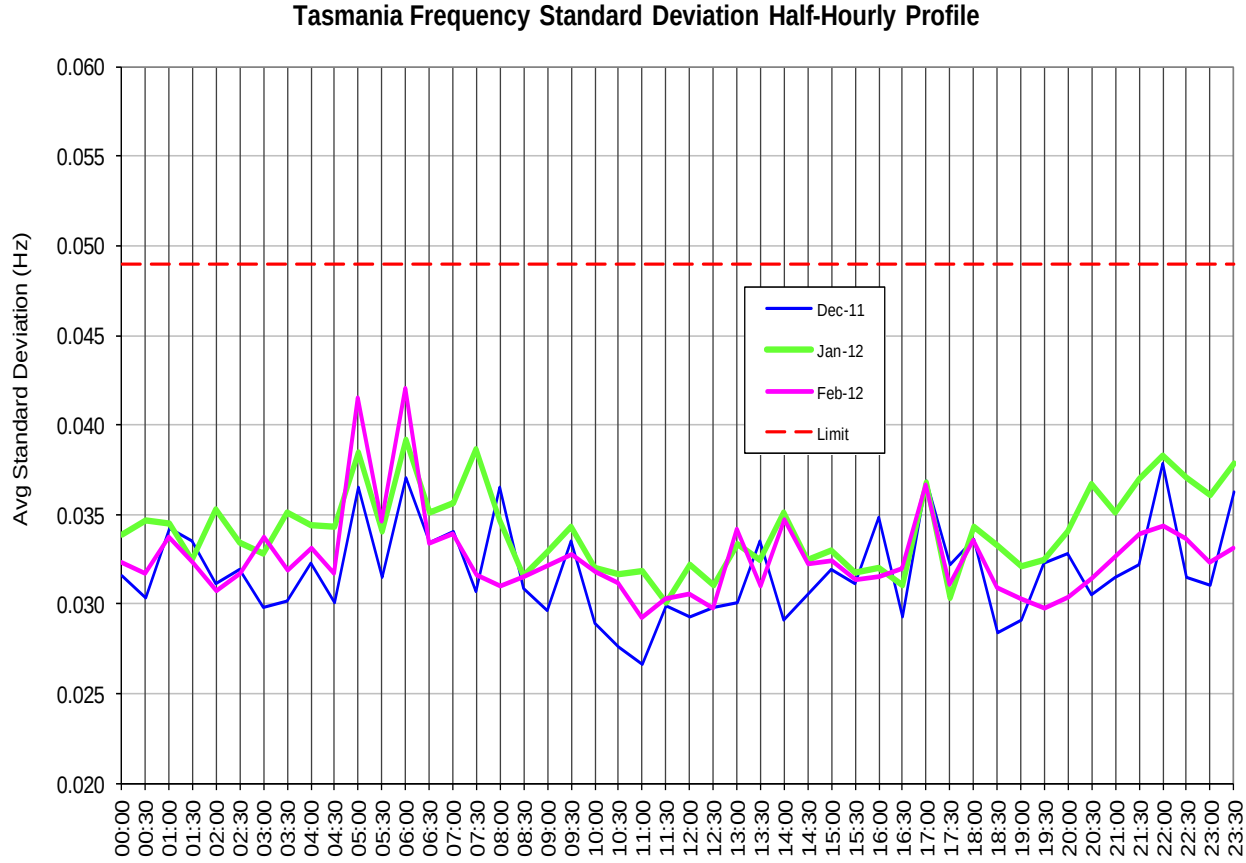

Figure 25: Daily profile of standard deviation for the frequency in Tasmania.

6 Accumulated Time Deviation

The frequency operating standards require that the accumulated time deviation be maintained within the range ± 5 seconds in Mainland regions and ± 15 seconds in Tasmania.

For a separation event there is no requirement in the frequency operating standards that time deviation be maintained within the ranges specified above.

The range of accumulated time deviations recorded throughout the NEM during February 2012 is provided in Table 5.

Table 5: Accumulated time deviation statistics

	QUEENSLAND	NSW	VIC	SA	TAS
Maximum Positive Deviation (s)	1.31	1.70	0.88	0.72	5.20
Maximum Negative Deviation (s)	-4.88	-4.57	-5.23	-5.48	-5.05
Mean Value (s)	-0.335	0.036	-0.743	-0.928	-0.034
Standard Dev (s)	0.575	0.574	0.577	0.575	1.723

The distribution of time deviations based on the Mainland regions measurement is provided in Figure 26.

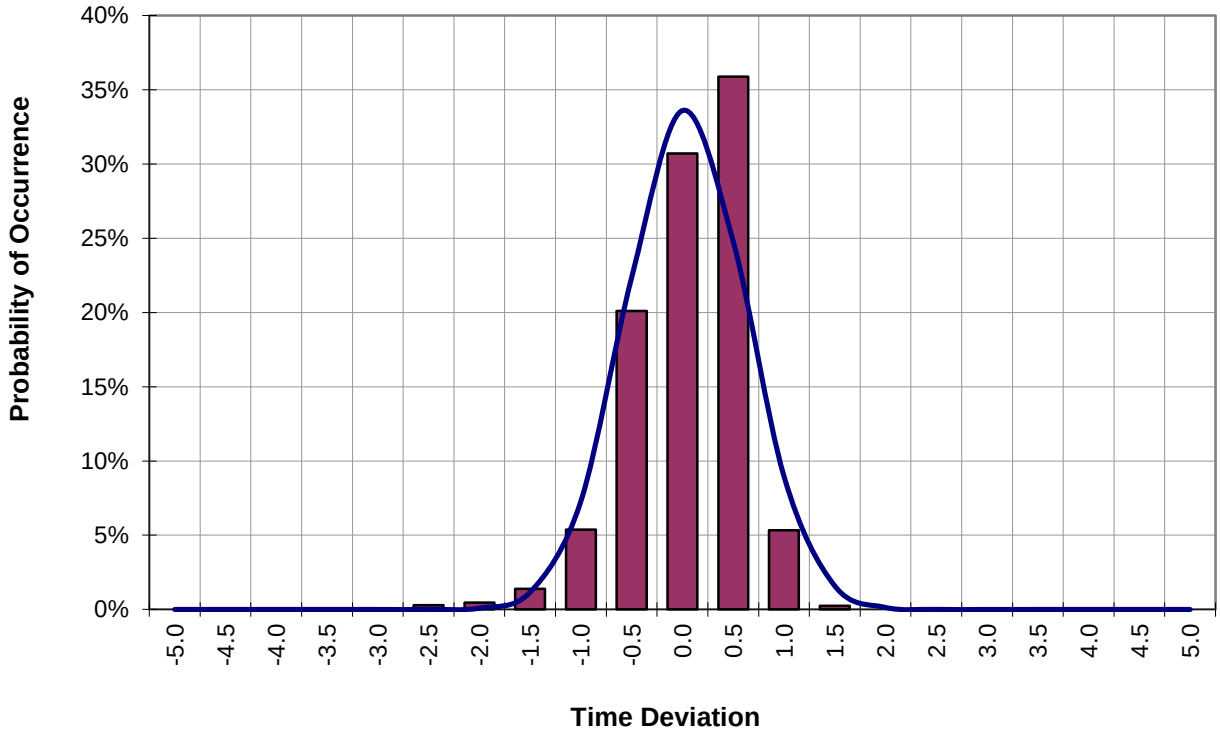

Figure 26: Mainland time deviation distribution for February 2012.

The distribution of time deviations based on the Tasmania region measurement is provided below in Figure 27.

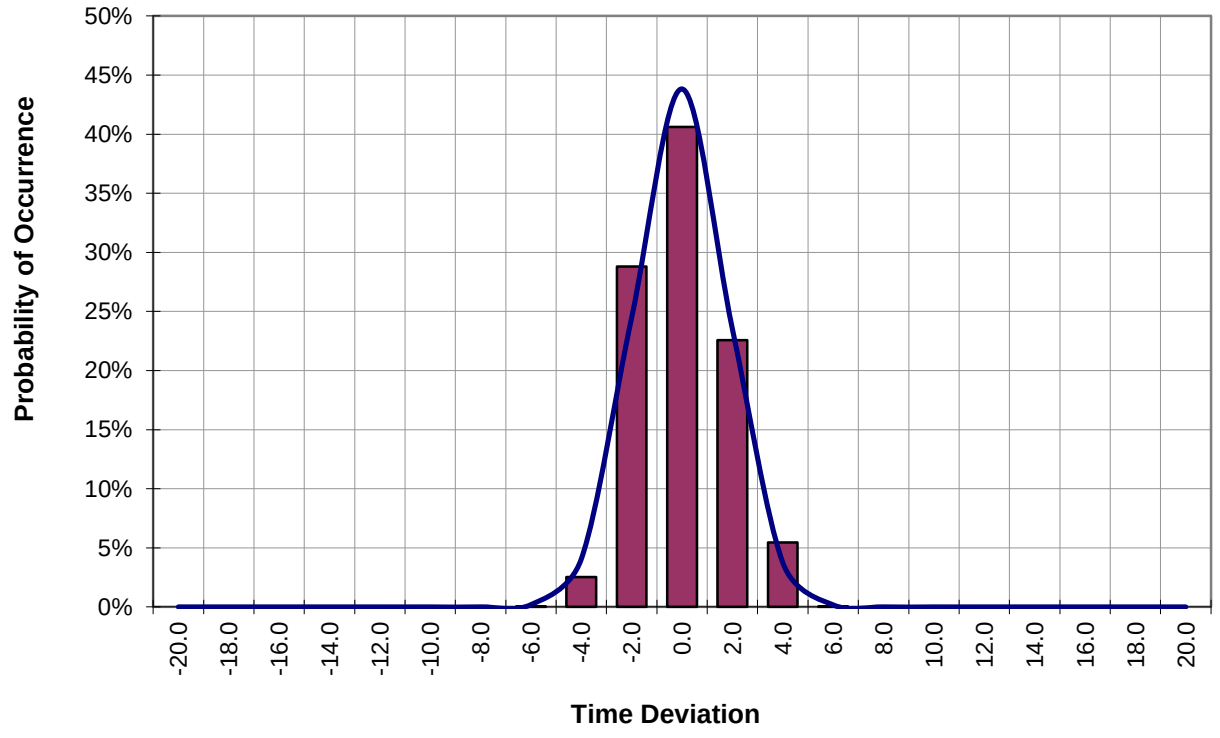

Figure 27: Tasmania time deviation distribution for February 2012.

6.1 Time Error Performance

Figure 28 and Figure 29 below present the daily maximum and minimum values of the Mainland and Tasmanian regions time error observed for the past 13 months.

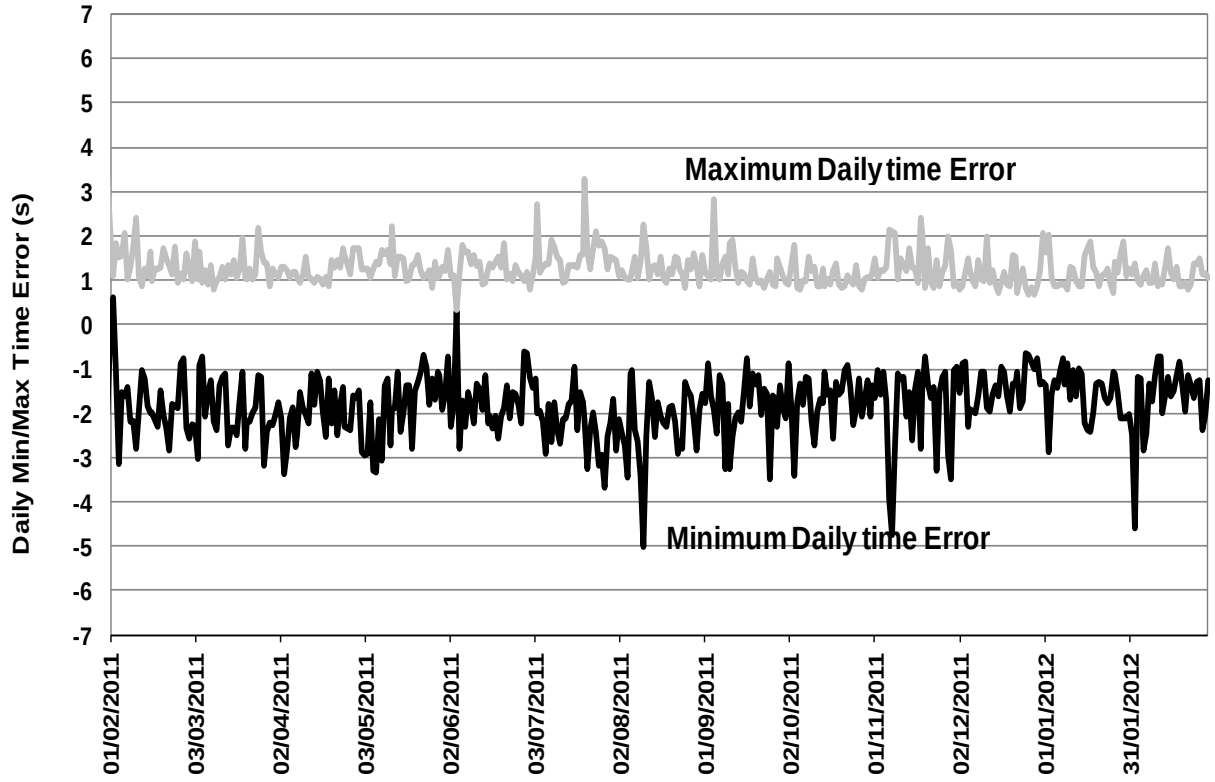

Figure 28: Mainland regions daily maximum and minimum time deviation.

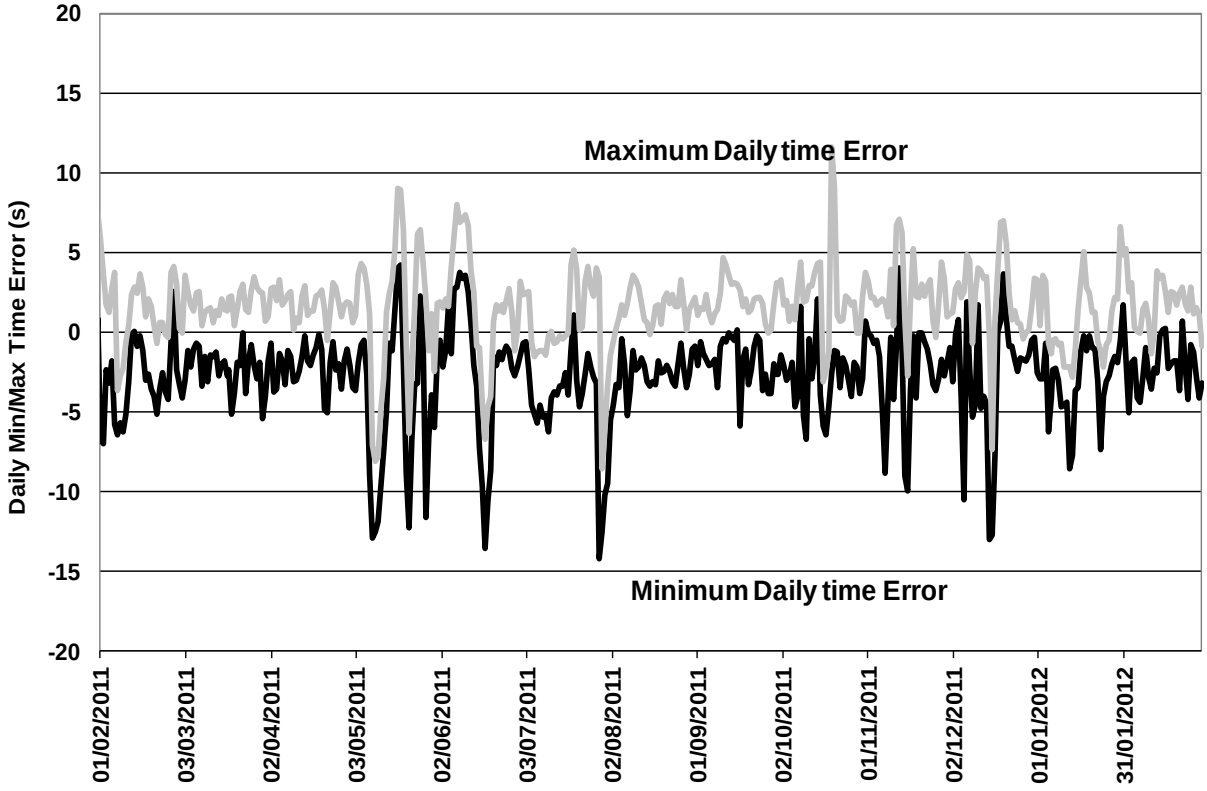

Figure 29: Tasmania daily maximum and minimum time deviation.