

POWER SYSTEM FREQUENCY AND TIME DEVIATION MONITORING

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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 October 2011 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 site¹.

The “Power System Frequency and Time Deviation Monitoring Report – Reference Guidelines²” 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 October 2011 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	70
	HIGH	0	38
Load Event	LOW	0	84
	HIGH	0	153
Generation Event	LOW	4	3
	HIGH	0	0
Network Event	LOW	0	0
	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 3.1 as not meeting the frequency operating standard applicable to each event.

4.1 Low frequency events in mainland regions

4.1.1 Generation Event

There was one Low Frequency Generation Event from Table 1 recorded in Mainland region during October 2011 that resulted in frequency below normal operating band 49.85 Hz, and failed to recover in 5 minutes. This event did not meet the Mainland Frequency Operating Standards, details are recorded in Table 2.

Table 2: Low Frequency Generation Events in the mainland region resulting in frequency below 49.85 Hz with recovery time exceeding 300 seconds.

DATE	EVENT	MAINLAND		TASMANIA (BASSLINK TRANSFERRING FCAS)	
		MIN FREQUENCY (HZ)	BELOW 49.85 HZ FOR (SECONDS)	MIN FREQUENCY (HZ)	BELOW 49.85 HZ OR ABOVE 50.15 HZ FOR (SECONDS)
18/10/2011 08:12:16	Generation Event in the mainland due to trip of Kogan Creek generating unit from 746 MW	49.726	438	49.659	392

On 18 October 2011 at 0812 hrs, Kogan Creek generating unit tripped from 746 MW. This resulted in the power system frequency deviating below the lower limit of the Mainland Frequency Operating Standards for 438 seconds as shown in Figure 2. Kogan Creek was not enabled for raise FCAS. In response to the low frequency generation event in Table 2, on 18 October 2011, the total amounts of Raise Slow and Raise Delayed services delivered by enabled plants can be seen in Figure 1. The net delivered R60 FCAS exceeded the enablement while the net delivered R5 FCAS was less than the enablement. The amount of Raise Fast services delivered was not calculated since 50 ms data was not requested for the event. Basslink transferred FCAS to the Mainland by reducing the export to Tasmania during the time of the frequency excursion in the Mainland. The Mainland frequency dropped to a minimum of 49.73 Hz which triggered some of the switched controllers to provide delayed FCAS in Mainland.

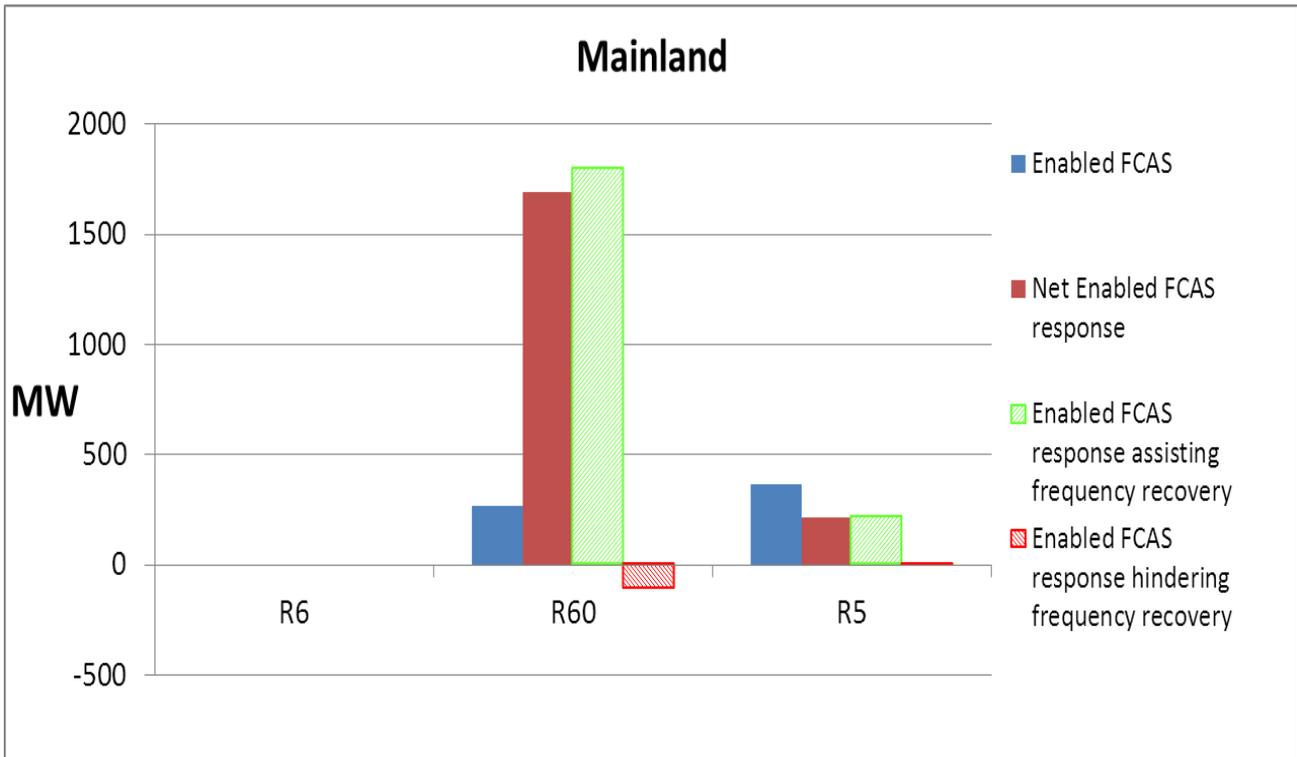


Figure 1: FCAS response to the Low Frequency Generation Event in the Mainland in Table 2.

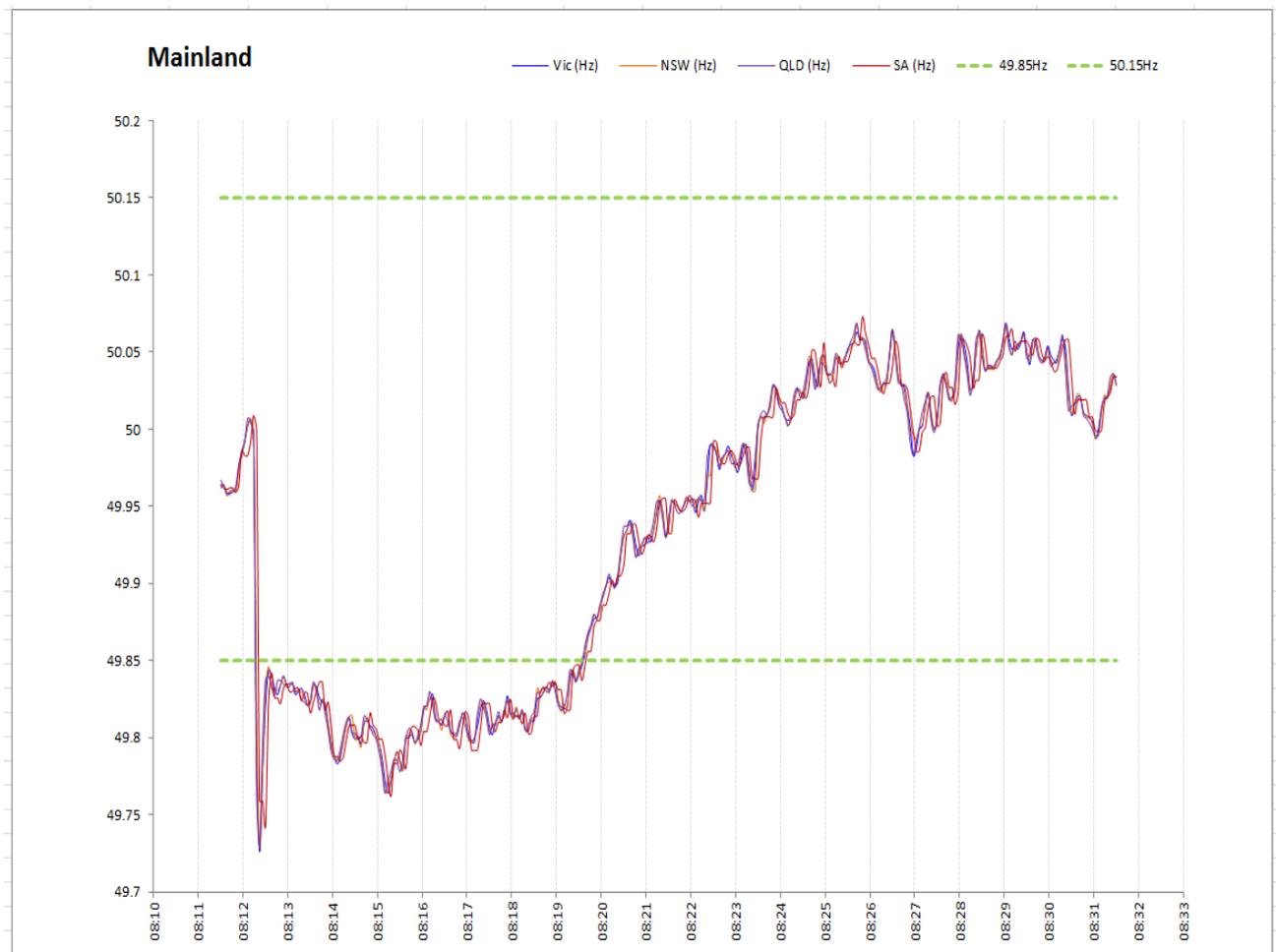


Figure 2: Mainland frequencies during low frequency generation event in Table 2 on 18th October 2011.

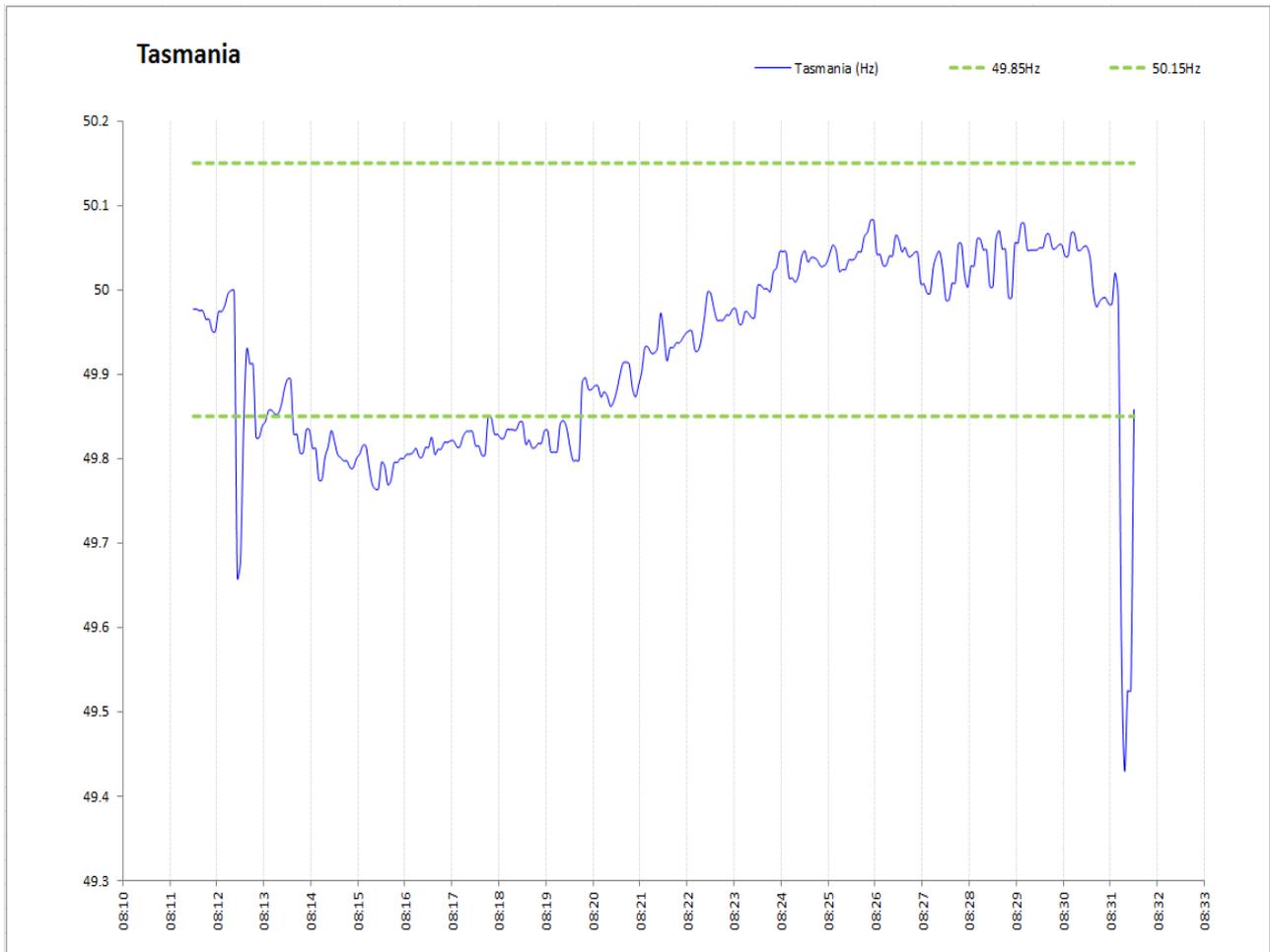


Figure 3: Tasmania frequency during low frequency Mainland generation event in Table 2 on 18th October 2011.

As a consequence of the low frequency in the Mainland region, the Basslink frequency controller operated to lower the frequency in Tasmania to provide FCAS service to the Mainland. Frequency fell to a minimum of 49.65 Hz in the Tasmanian region as shown in Figure 3 above. This event is within the Tasmania Frequency Operating Standards since the Tasmania frequency recovered within 392 seconds, well within the Frequency Operating Standard of 600 seconds for recovery.

Figure 3 also shows another low frequency excursion that occurs soon after 0831 hrs. This relates to a load event in the Tasmania region and is within the Tasmania Frequency Operating Standards.

4.2 Low frequency events in Tasmania

There were six Low Frequency No contingency events from Table 1 in Tasmania during October 2011, which resulted in frequencies below the threshold frequency of 49.75 Hz. All of these events listed in Table 3 did not meet the Tasmania Frequency Operating Standards.

Table 3: Low Frequency Normal Condition Events (No Contingency) in the Tasmania region that did not meet the Tasmania Frequency Operating Standards in October 2011.

DATE	EVENT	MIN FREQUENCY (HZ)	TIME OUTSIDE NORMAL OPERATING BAND (49.85 HZ - 50.15 HZ)
20/10/2011 22:36:48	No condition causing the event was identified.	49.73	12
21/10/2011 22:36:52	No condition causing the event was identified.	49.73	8
23/10/2011 07:35:56	No condition causing the event was identified.	49.74	20
23/10/2011 23:06:24	No condition causing the event was identified.	49.73	8
27/10/2011 01:01:36	No condition causing the event was identified.	49.68	288
30/10/2011 04:06:08	No condition causing the event was identified.	49.69	68

4.2.1 Event: 20/10/2011 22:36:48

For the Normal (Non-Contingency) low frequency event on 20th October 2011 in Tasmania, Figure 4 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 12 seconds. A Tasmanian generating unit rapidly ramped down its generation to zero in order to follow its dispatch target, thus contributing to the low frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 5. Basslink was not in service at the time of the 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.

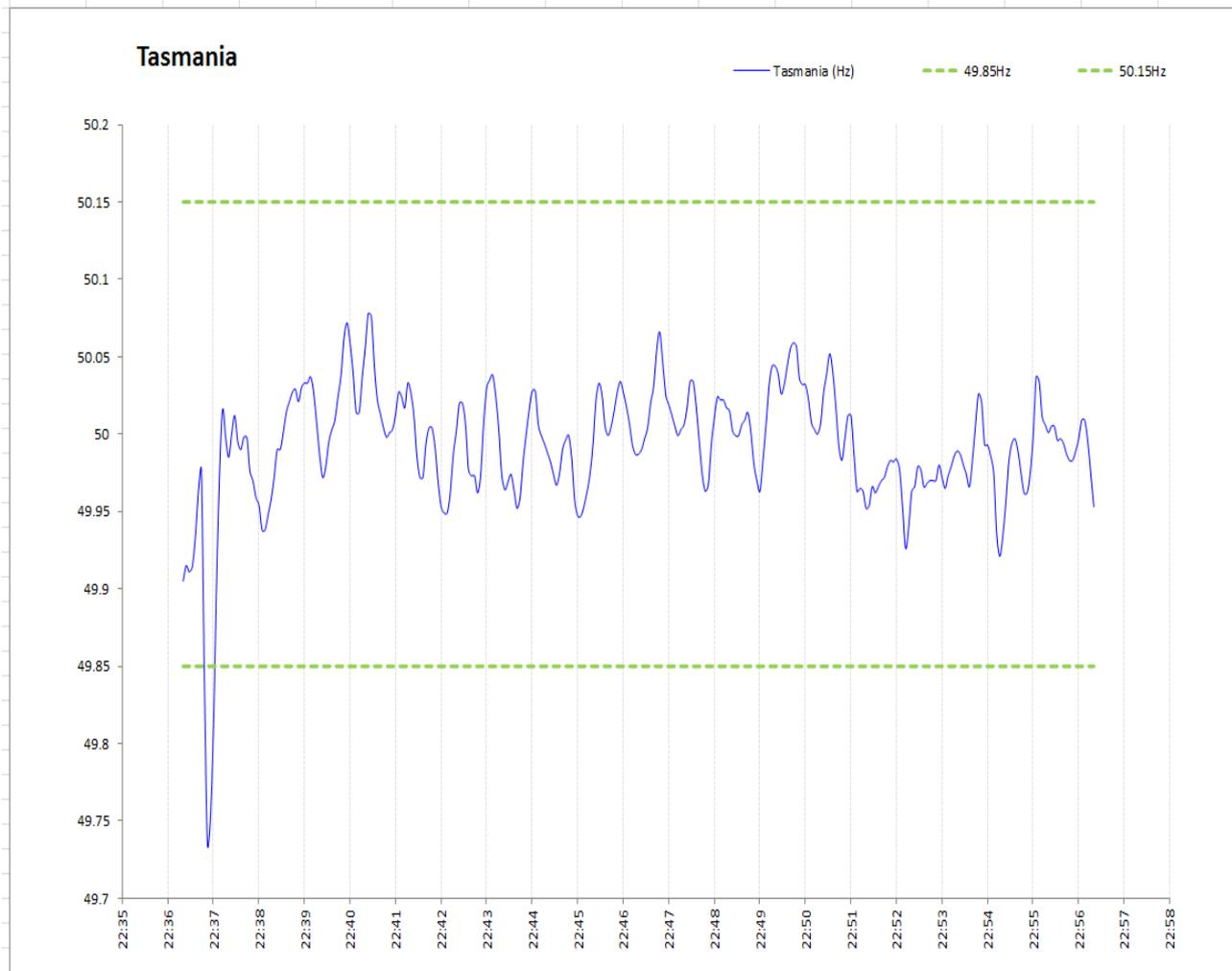


Figure 4: Tasmania frequency during Low frequency No contingency event in Table 3 on 20th October 2011.

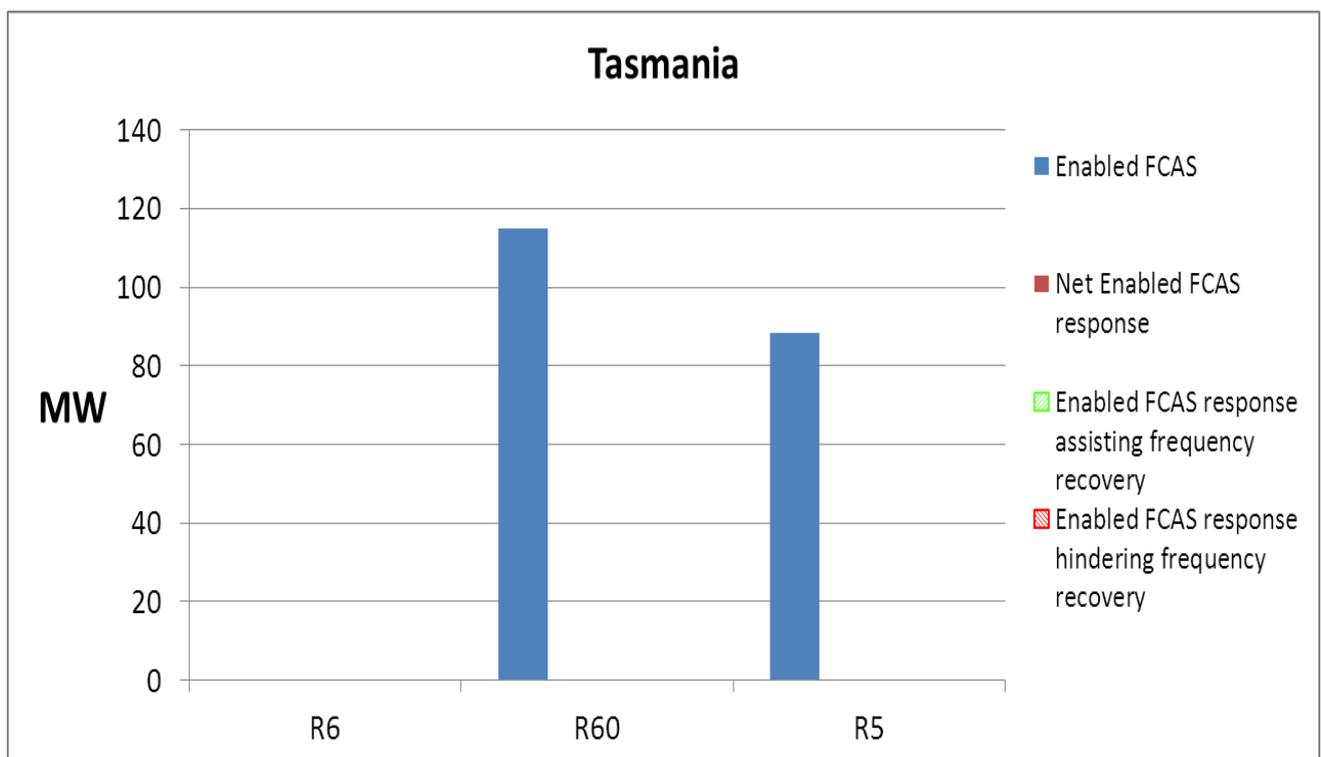


Figure 5: FCAS response to Normal (Non-Contingency) Low Frequency Event on 20th October 2011.

4.2.2 Event: 21/10/2011 22:36:52

For the Normal (Non-Contingency) low frequency event on 21st October 2011 in Tasmania, Figure 6 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 8 seconds. A Tasmanian generating unit rapidly ramped down its generation to zero in order to follow its dispatch target. Another generating unit was generating fairly below its dispatch target which could have contributed to the frequency excursion as well. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 7. Basslink was not in service at the time of the 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.

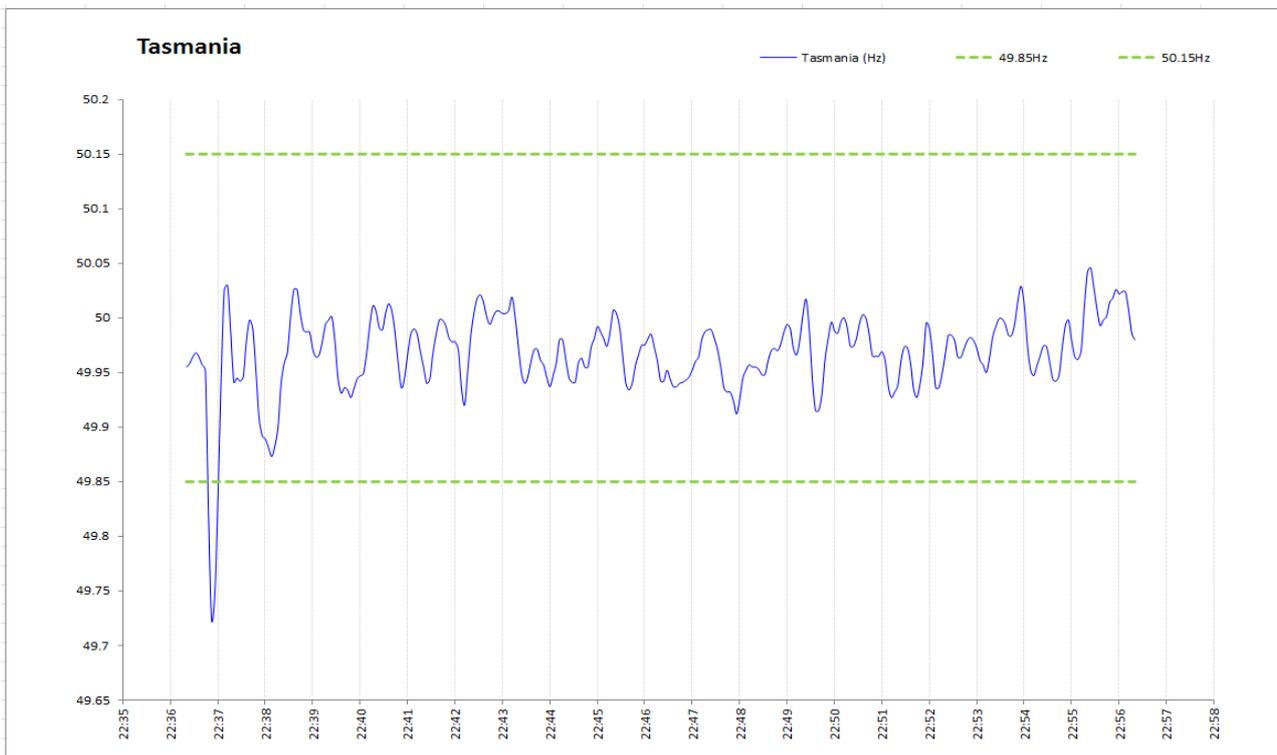


Figure 6: Tasmania frequency during Low frequency No contingency event in Table 3 on 21st October 2011.

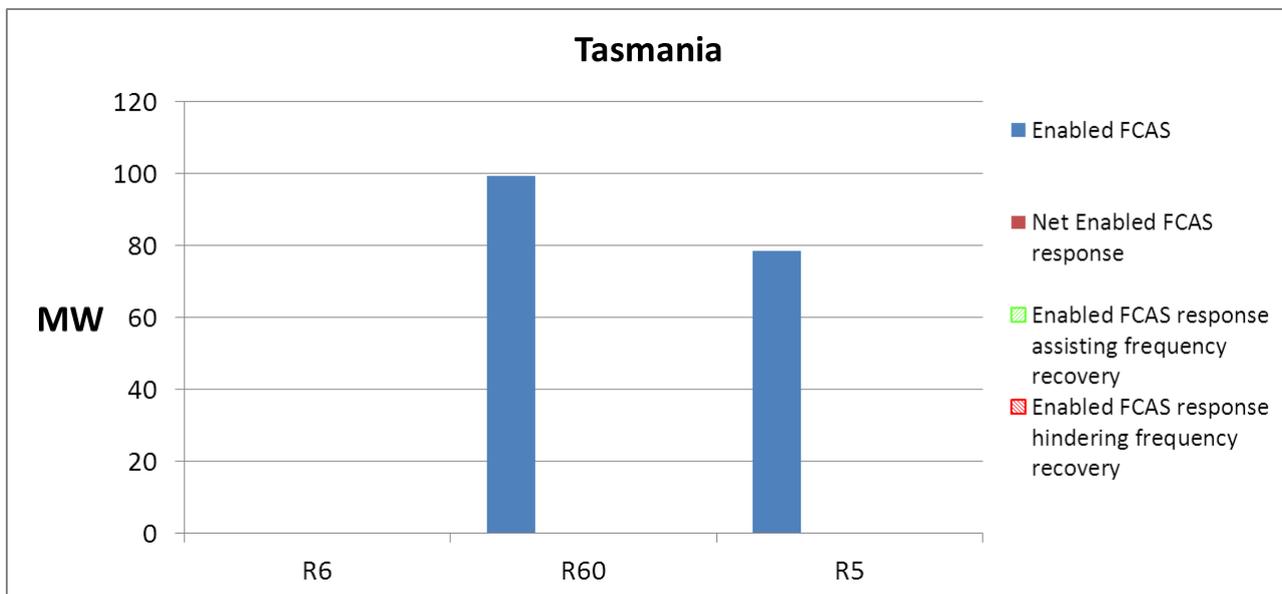


Figure 7: FCAS response to Normal (Non-Contingency) Low Frequency Event on 21st October 2011.

4.2.3 Event: 23/10/2011 07:35:56

For the Normal (Non-Contingency) low frequency event on 23rd October 2011 in Tasmania, Figure 8 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 20 seconds. A major load in Tasmania was ramping up to normal load levels after an earlier reduction. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 9. Basslink was not in service at the time of the event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.74 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.

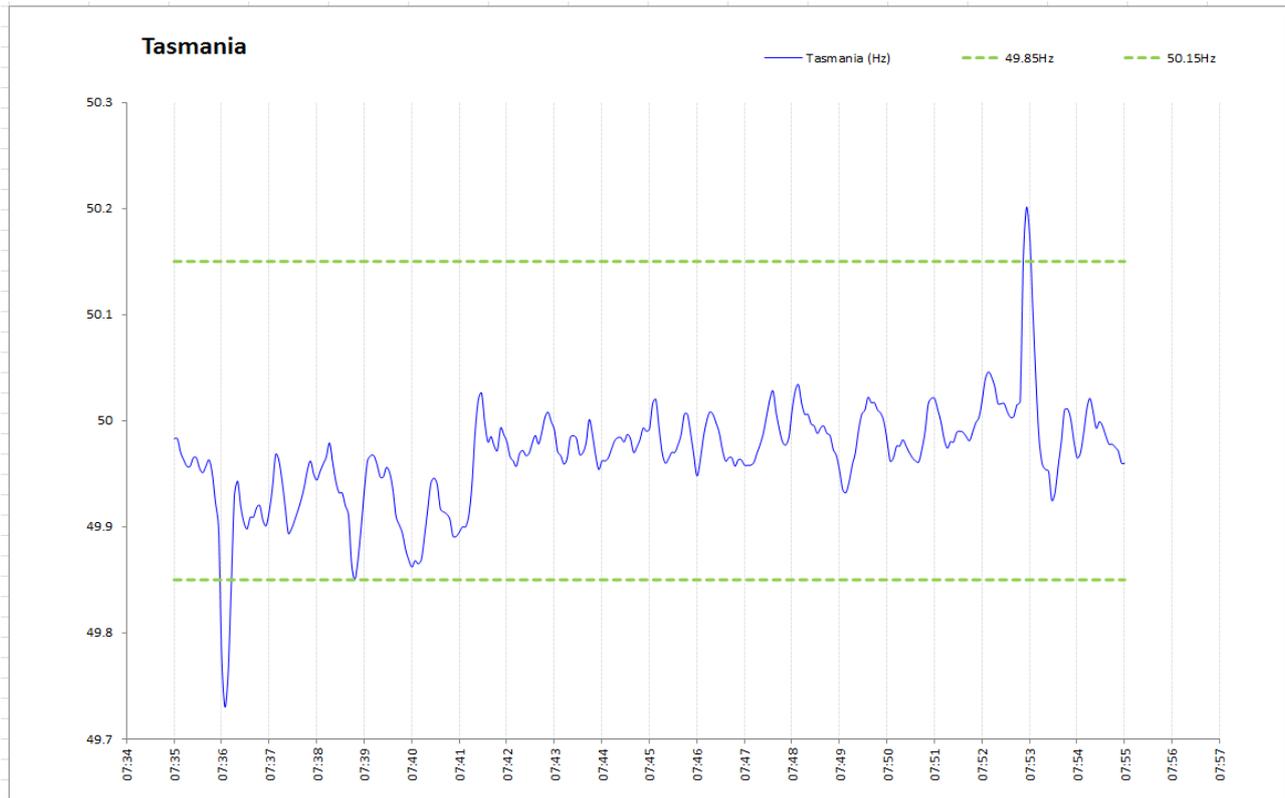


Figure 8: Tasmania frequency during Low frequency No contingency event in Table 3 on 23rd October 2011 at 0735 hrs.

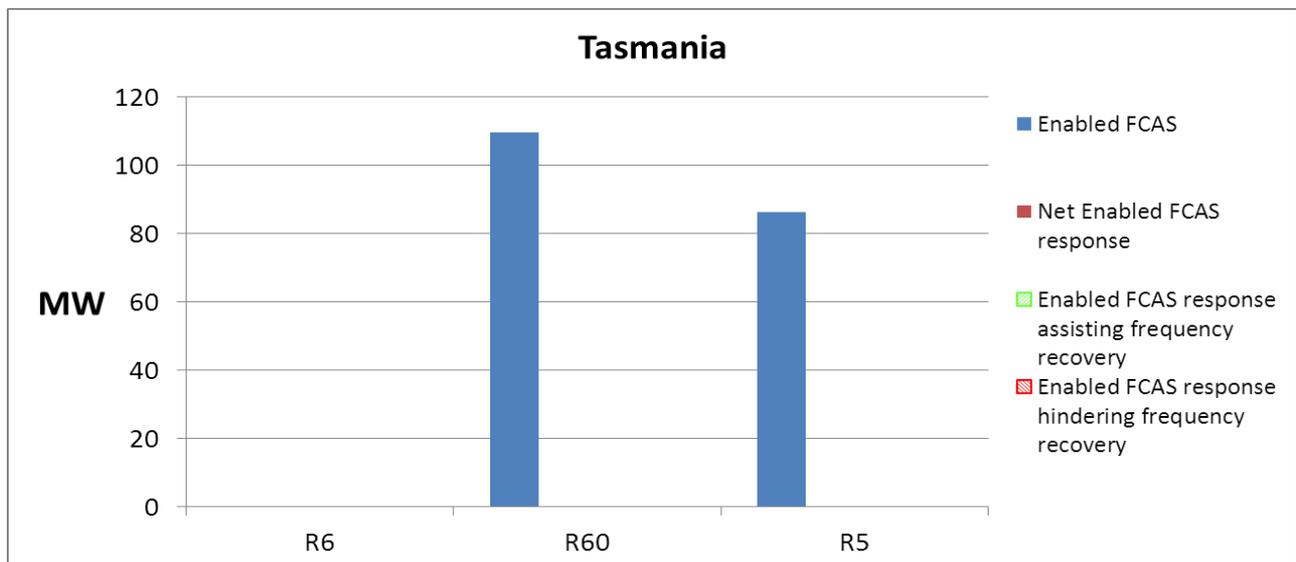


Figure 9: FCAS response to Normal (Non-Contingency) Low Frequency Event on 23rd October 2011 at 0735 hrs.

4.2.4 Event: 23/10/2011 23:06:24

For the Normal (Non-Contingency) low frequency event on 23rd October 2011 in Tasmania, Figure 10 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 8 seconds. A Tasmanian generating unit rapidly ramped down its generation to zero in order to follow its dispatch target. The non-scheduled generation in Tasmania reduced during the period of frequency excursion which could have contributed to the low frequency event as well. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 11. Basslink was not in service at the time of the 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.

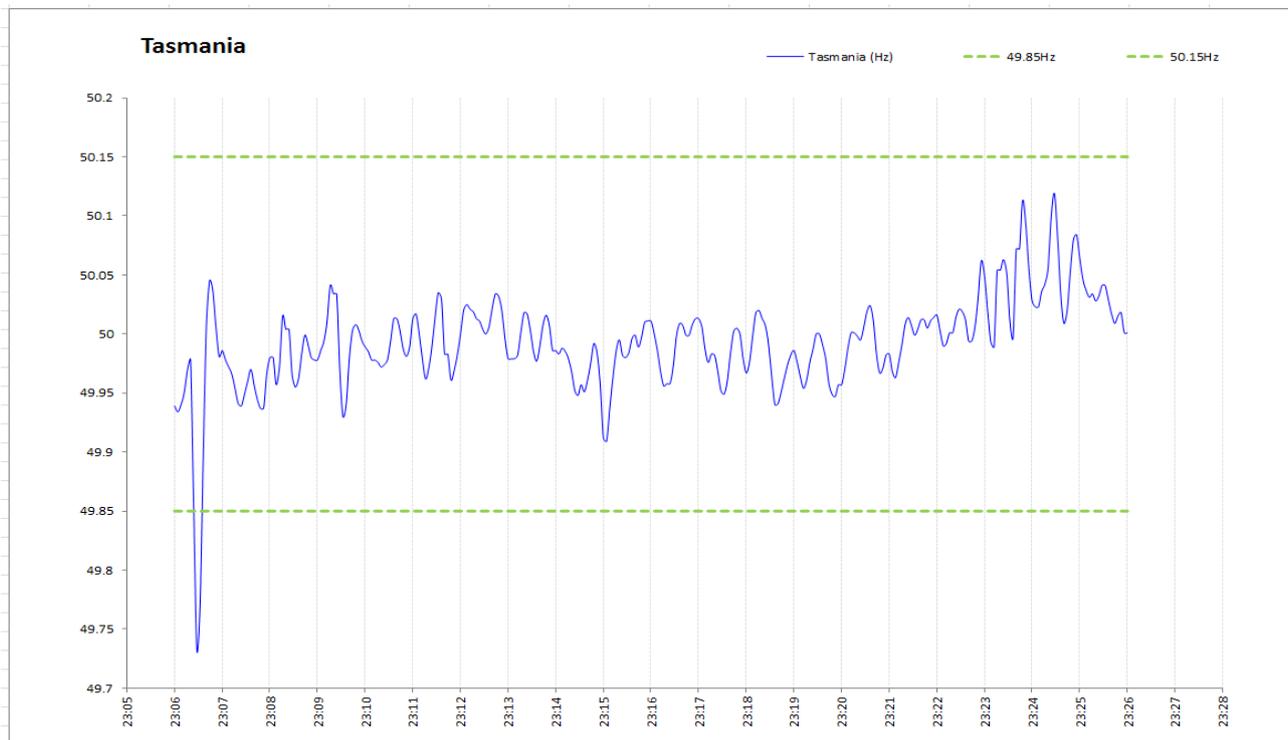


Figure 10: Tasmania frequency during Low frequency No contingency event in Table 3 on 23rd October 2011 at 2306 hrs.

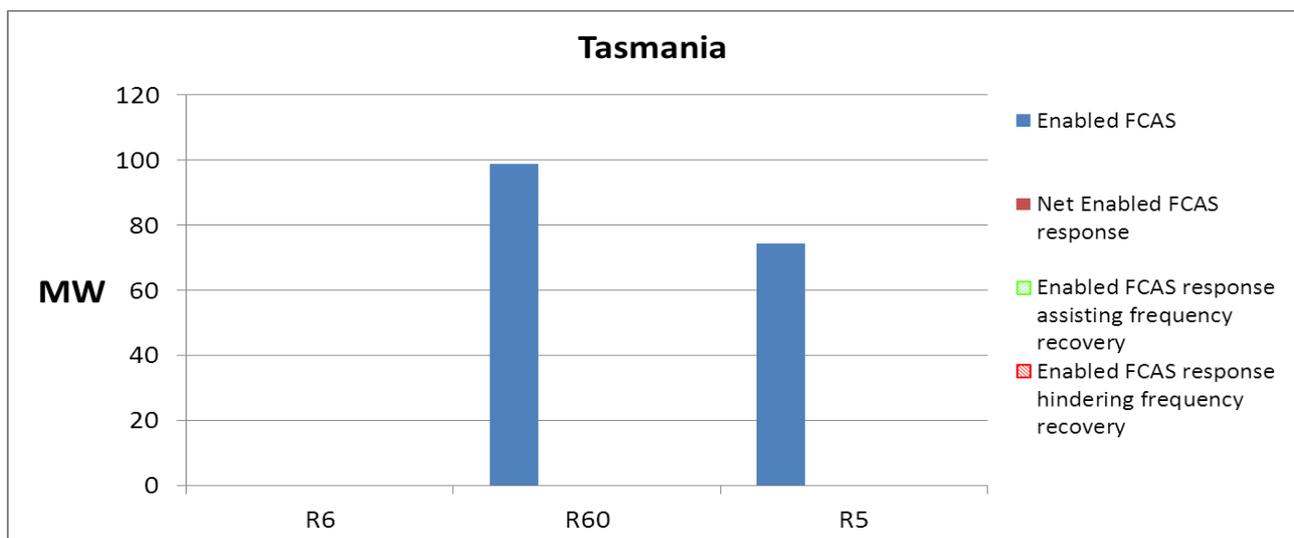


Figure 11: FCAS response to Normal (Non-Contingency) Low Frequency Event on 23rd October 2011 at 2306 hrs.

4.2.5 Event: 27/10/2011 01:01:36

For the Normal (Non-Contingency) low frequency event on 27th October 2011 in Tasmania, Figure 12 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 288 seconds. Basslink had tripped out of service prior to the event and was attempting to come back online. Basslink received targets for import (Victoria to Tasmania) at 0100 hrs, however there was no actual flow across Basslink. This could have contributed to the low frequency excursion in Tasmania. As seen in Figure 13, the amount of slow FCAS response delivered was less than the amount of slow FCAS response enabled. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.68 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.

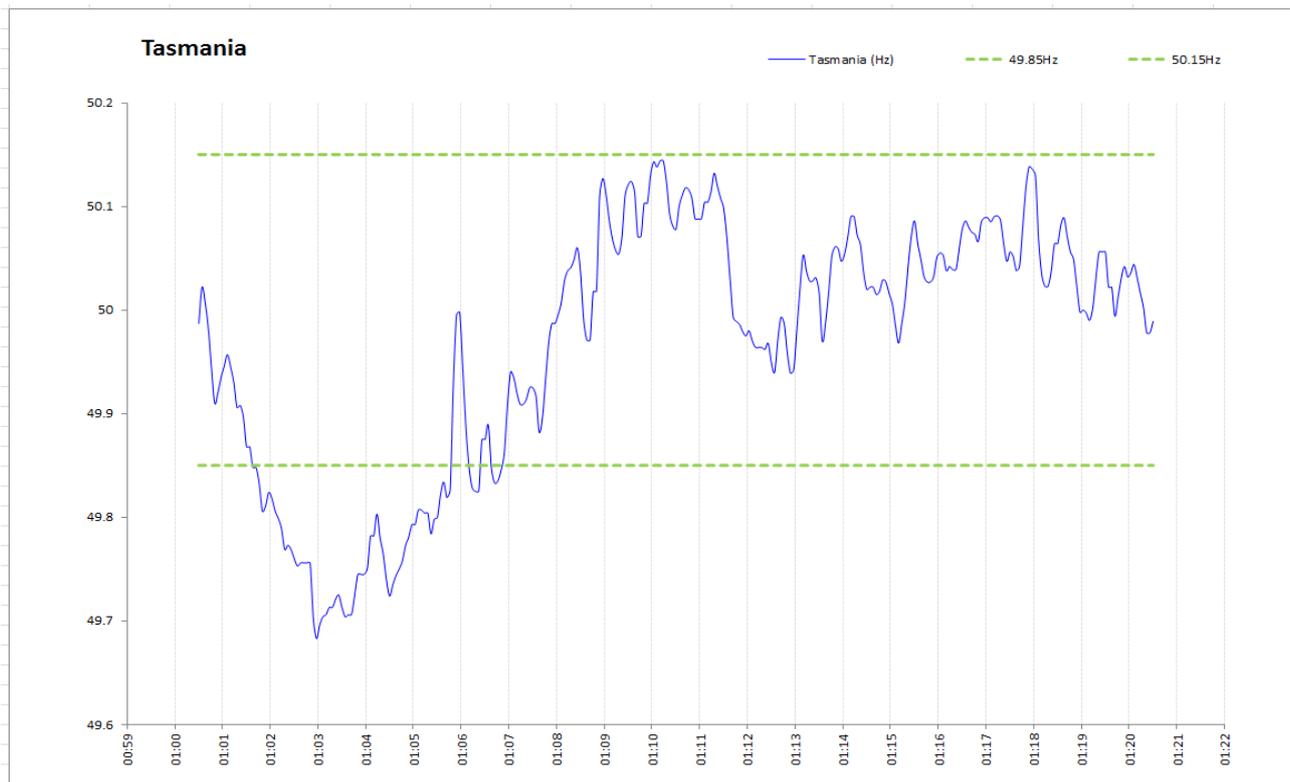


Figure 12: Tasmania frequency during Low frequency No contingency event in Table 3 on 27th October 2011.

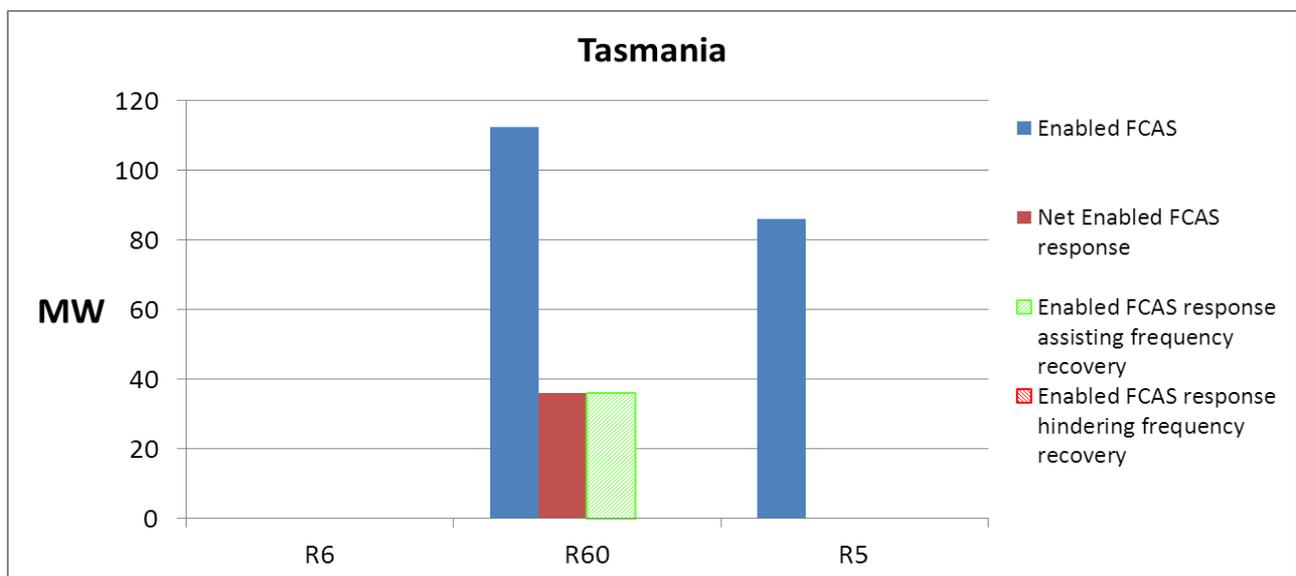


Figure 13: FCAS response to Normal (Non-Contingency) Low Frequency Event on 27th October 2011.

4.2.6 Event: 30/10/2011 04:06:08

For the Normal (Non-Contingency) low frequency event on 30th October 2011 in Tasmania, Figure 14 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 68 seconds. A major load in Tasmania was ramping up to normal load levels after an earlier reduction which could have contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 15. Basslink provided FCAS support by increasing import into Tasmania. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.69 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.

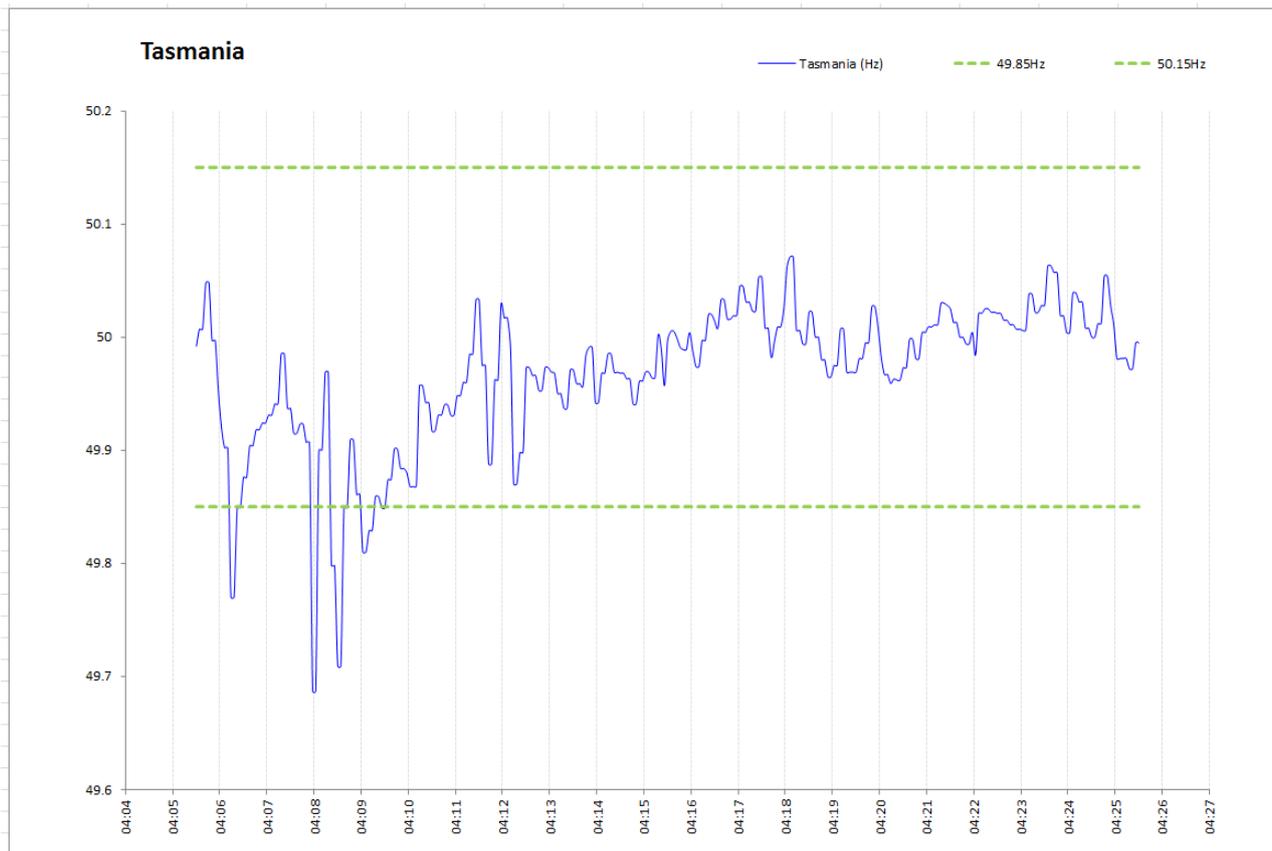


Figure 14: Tasmania frequency during Low frequency No contingency event in Table 3 on 30th October 2011.

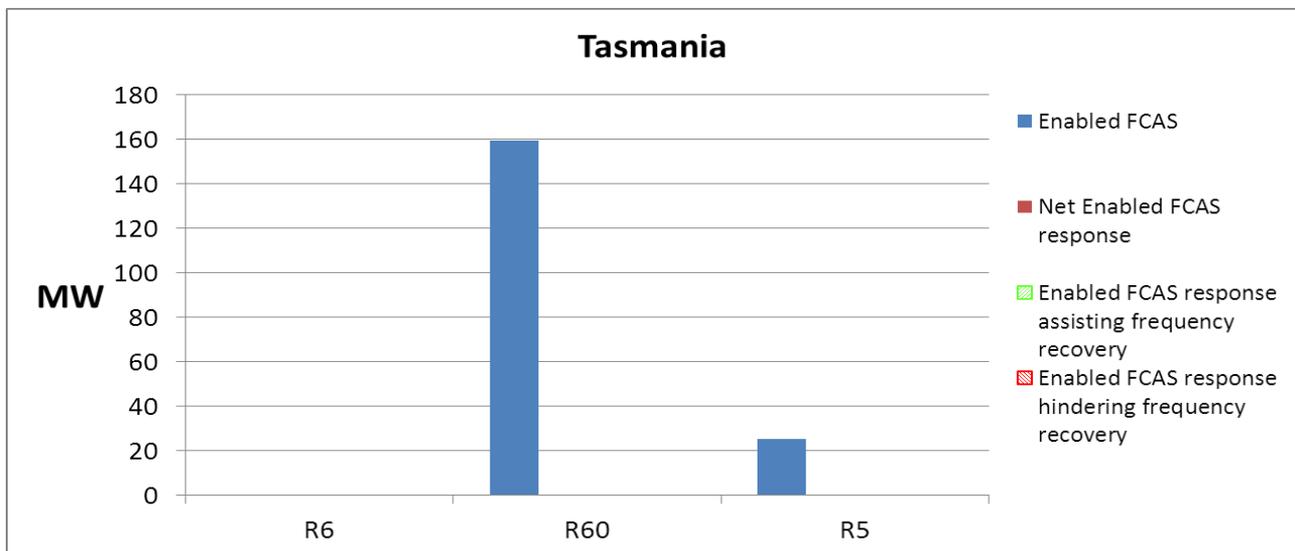


Figure 15: FCAS response to Normal (Non-Contingency) Low Frequency Event on 30th October 2011.

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 October 2011.

Frequency in the mainland regions was within the range 49.91 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 October 2011 was 50 Hz with a standard deviation of 0.030 Hz.

Frequency in the Tasmania region was within the range 49.90 – 50.09 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 frequency was outside the range 49.75 Hz – 50.25 Hz for 0.02% of the time. The mean value of frequency during October 2011 was 50 Hz with a standard deviation of 0.038 Hz.

5.1.1 Daily frequency standard deviation

Figure 16 and Figure 17 below plot the daily standard deviation of the Mainland and Tasmanian frequency for the past 13 months, and do not exclude load and contingency events.

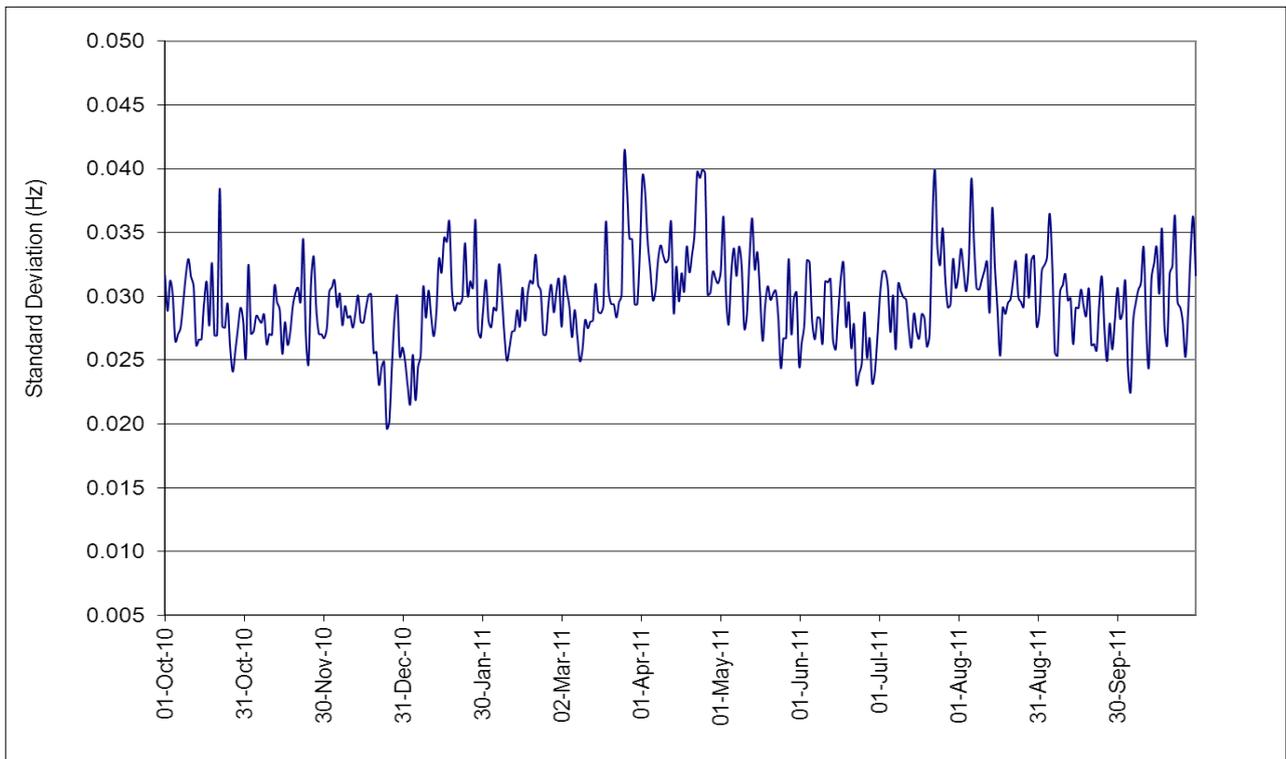


Figure 16: Daily standard deviation of mainland frequency.

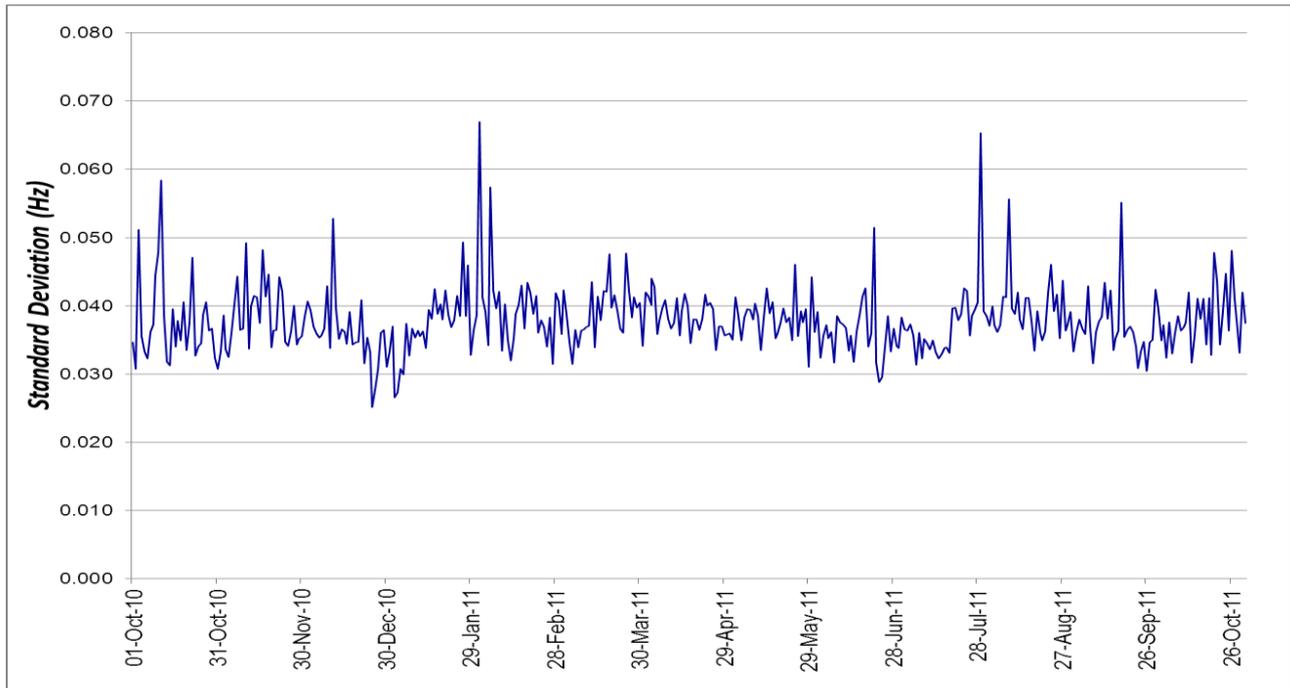


Figure 17: Daily standard deviation of frequency in Tasmania.

5.1.2 Time of day analysis

This section details the standard deviation of system frequency on a monthly and daily basis. Figure 18 and Figure 19 show the average half-hourly standard deviation of the mainland regions and Tasmania frequency for August, September and October 2011. 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 18 and Figure 19 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).

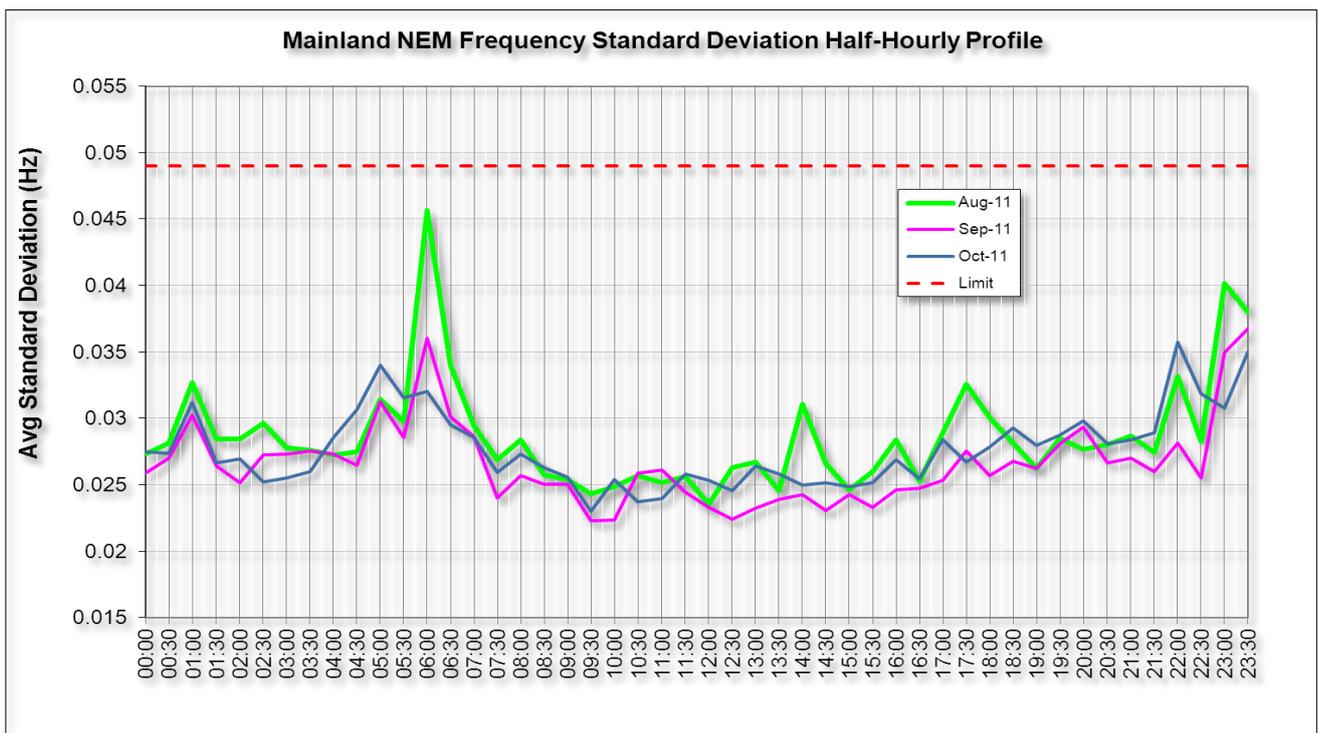


Figure 18: Daily profile of standard deviation for the frequency in the mainland regions.

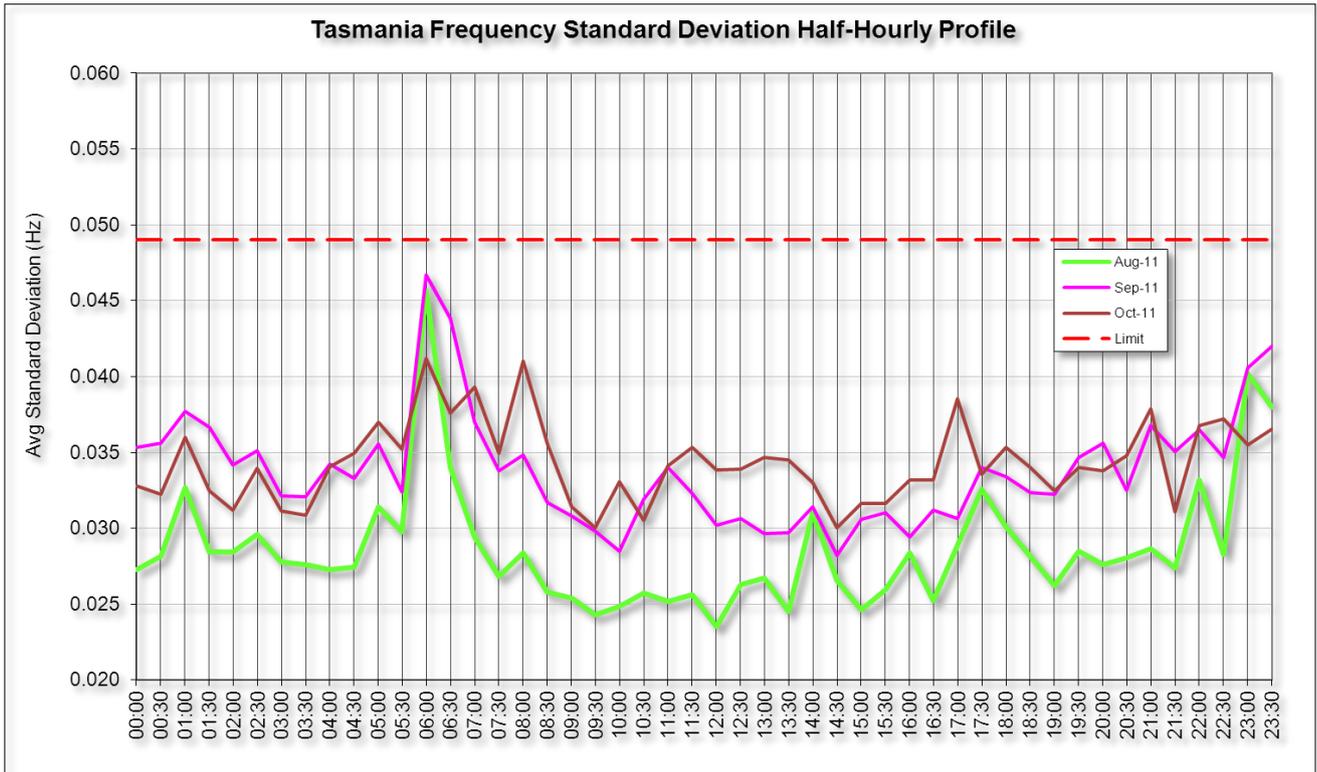


Figure 19: Daily profile of standard deviation for the frequency in the mainland regions.

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 October 2011 is provided in Table 4.

Table 4: Accumulated time deviation statistics.

	QUEENSLAND	NSW	VIC	SA	TAS
Maximum Positive Deviation (s)	1.69	1.81	1.47	1.28	11.59
Maximum Negative Deviation (s)	-3.51	-3.40	-3.74	-3.93	-6.77
Mean Value (s)	-0.039	0.043	-0.263	-0.486	-0.013
Standard Dev (s)	0.563	0.560	0.564	0.562	2.382

The distribution of time deviations based on the mainland regions measurement is provided in Figure 20.

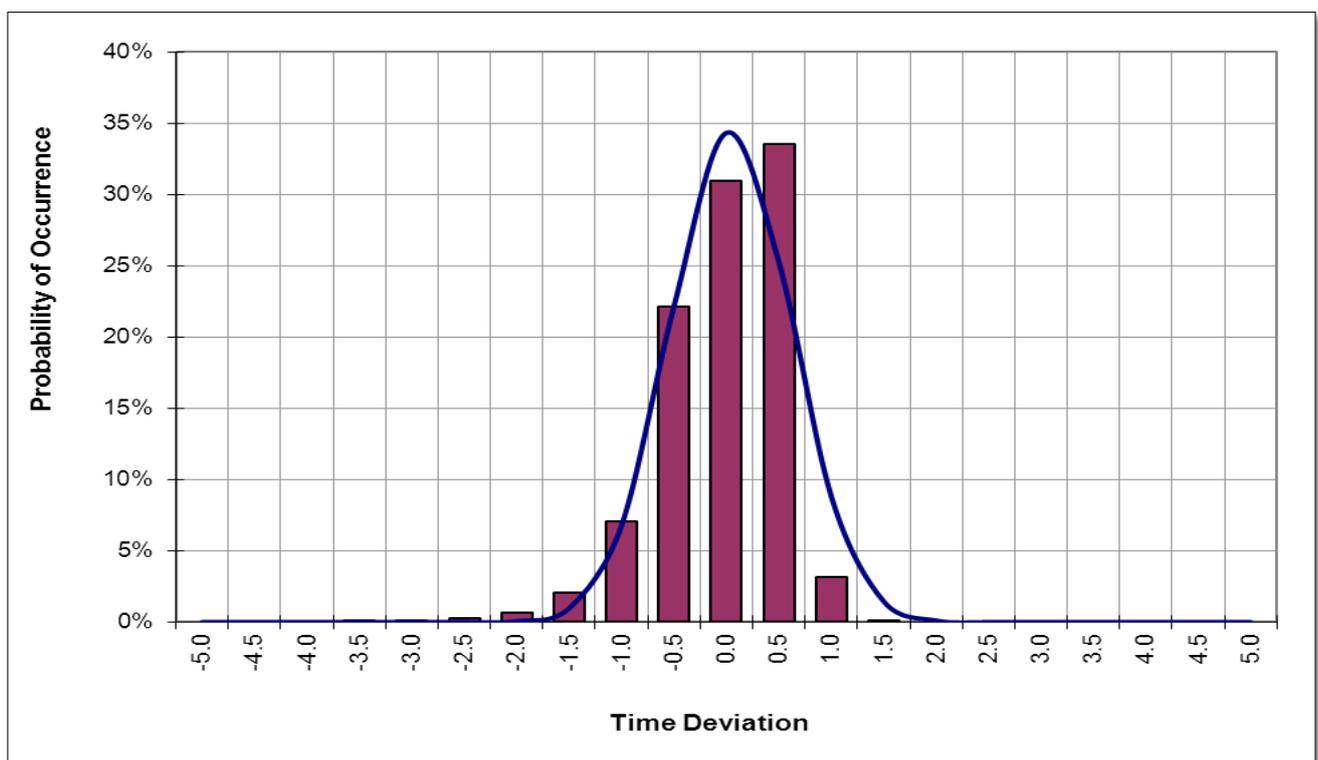


Figure 20: Mainland time deviation distribution for October 2011.

The distribution of time deviations based on the Tasmania region measurement is provided below in Figure 21.

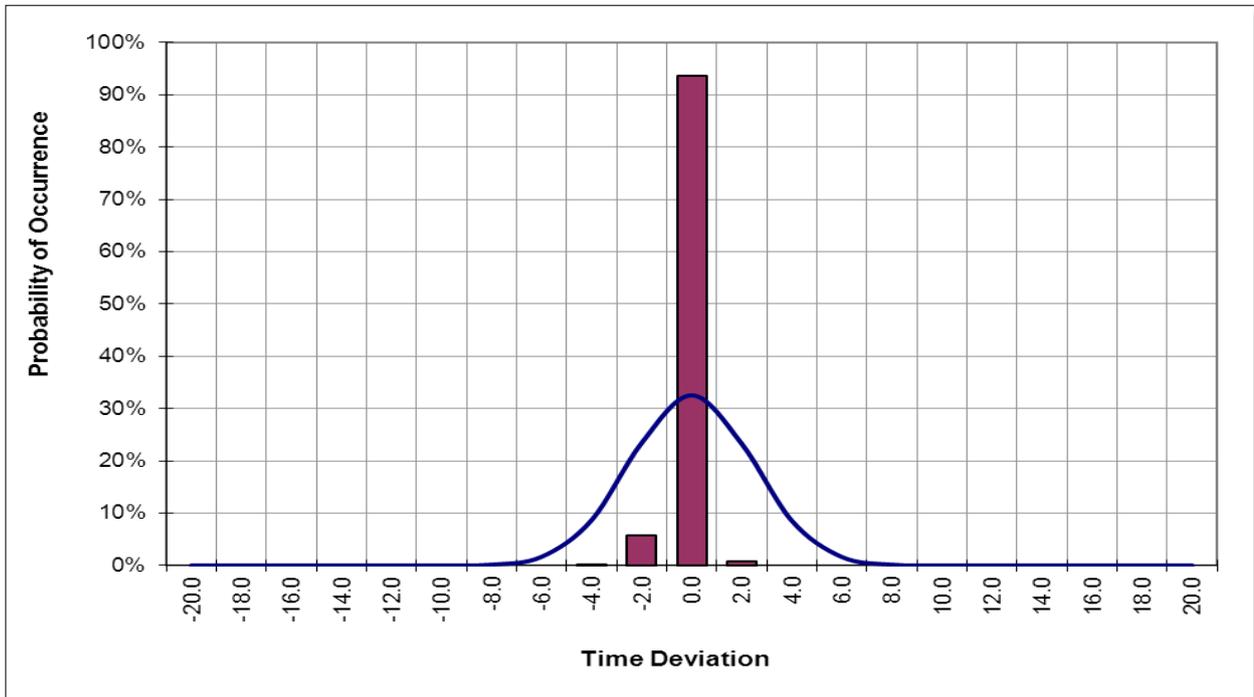


Figure 21: Tasmania time deviation distribution for October 2011.

6.1 Time error performance

Figure 22 below presents the daily maximum and minimum values of the mainland regions time error observed for the past 13 months.

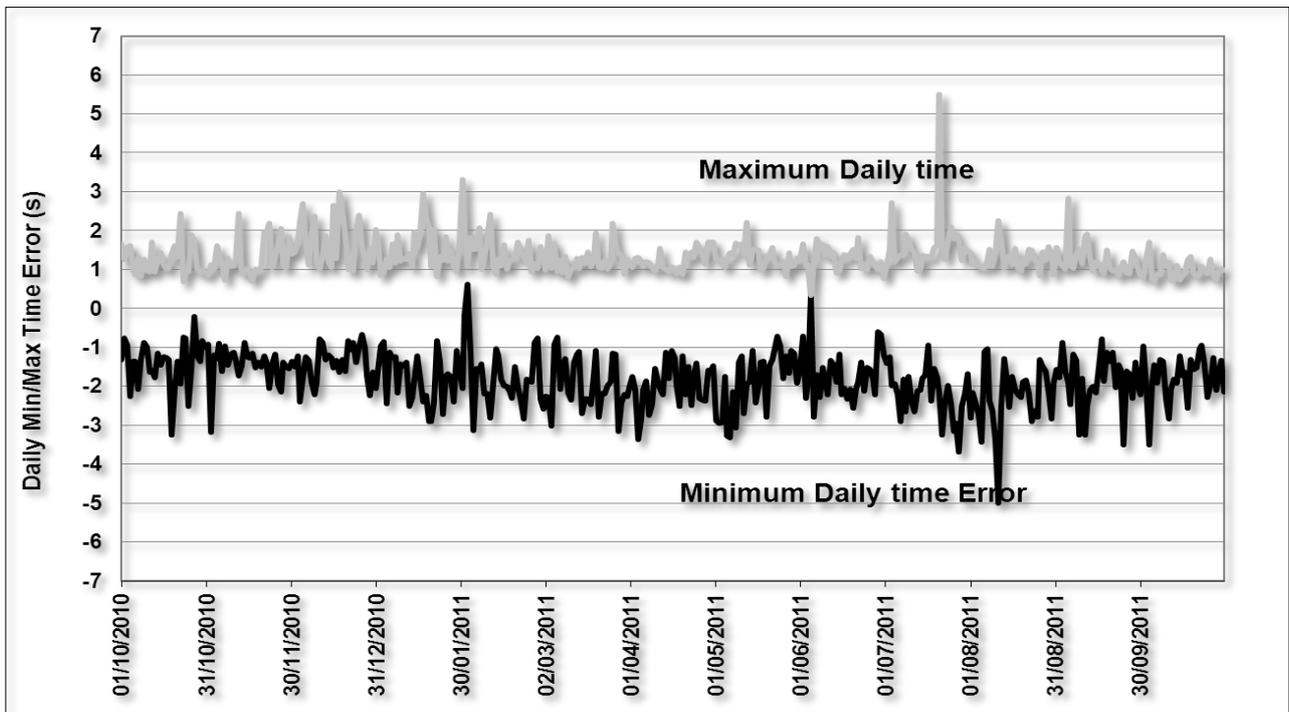


Figure 22: Mainland regions daily maximum and minimum time deviation.

Figure 23 presents the daily maximum and minimum values of Tasmania time error observed for the past 13 months.

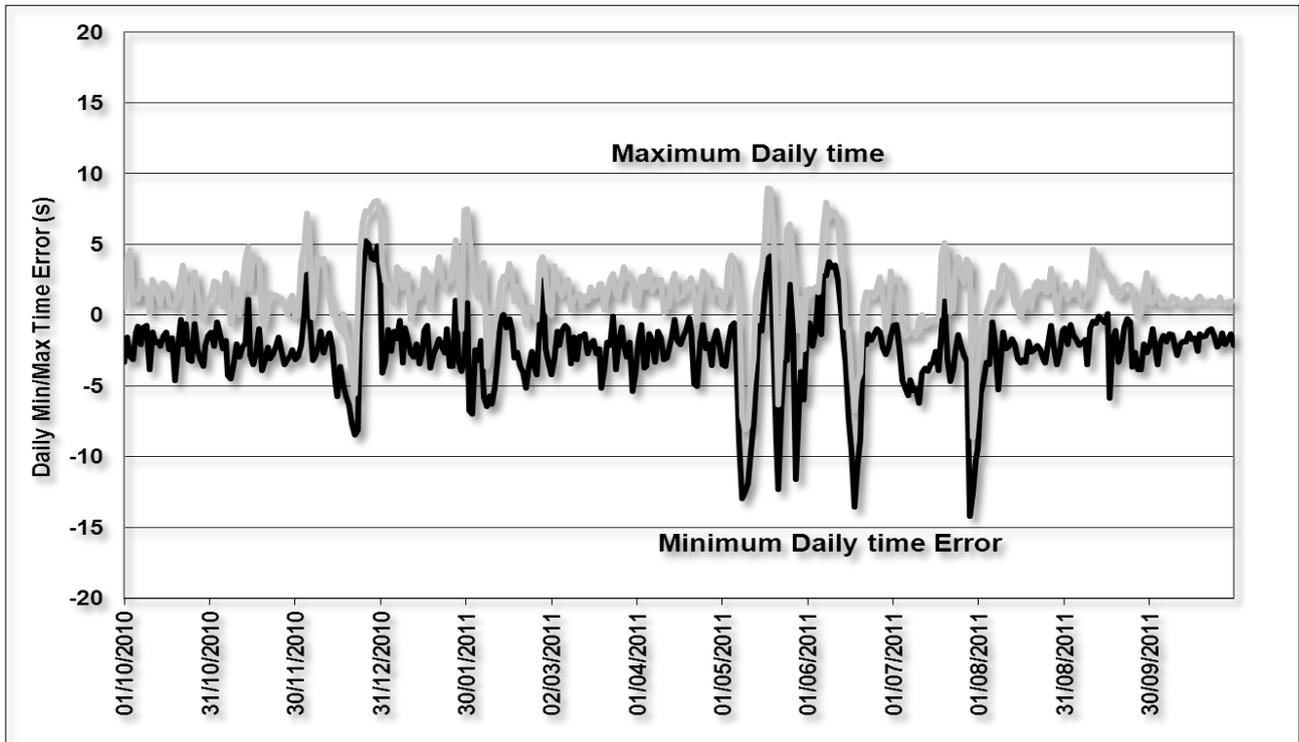


Figure 23: Tasmania daily maximum and minimum time deviation.