POWER SYSTEM FREQUENCY AND TIME DEVIATION MONITORING

November 2011

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Contents

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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 November 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 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 November 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 Guidelines 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	**2**	**47**
	HIGH	**0**	**21**
Load Event	LOW	**1**	**91**
	HIGH	**0**	**136**
Generation Event	LOW	**9**	**10**
	HIGH	**0**	**1**
Network Event	LOW	**0**	**0**
	HIGH	**0**	**0**
Separation Event	LOW	**1**	**1**
	HIGH	**1**	**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 Generation Events in Mainland Regions

There were three Low Frequency Generation Events from Table 1 recorded in the Mainland region during November 2011 that resulted in frequency below normal band (49.85 Hz ~ 50.15 Hz). All of these events listed in Table 2 did not meet the Mainland Frequency Operating Standards because the Mainland frequency failed to recover in 5 minutes, the details of the events have been recorded in Table 2.

Table 2: Low Frequency Generation Events in the Mainland region that did not meet the Mainland Frequency Operating Standards in November 2011.

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)
04/11/2011 15:01:28	Generation Event in the Mainland due to trip of Kogan Creek generating unit from 720 MW	49.658	312	49.075	260
07/11/2011 11:55:52	Generation Event in the Mainland due to trip of Loy Yang A Unit 2 from 500 MW	49.729	316	49.575	284
29/11/2011 07:41:16	Generation Event in the Mainland due to trip of Newport generating unit from 495 MW	49.793	396	49.793	260

4.1.1 Generation Event: 04/11/2011 15:01:28

On 04 November 2011 at 1501 hrs, Kogan Creek generating unit tripped from 720 MW This resulted in the power system frequency deviating below the lower limit of the Mainland Frequency Operating Standards for 312 seconds as shown in Figure 1. Kogan Creek was not enabled for raise FCAS.

In response to the low frequency generation event on 04 November 2011 in Mainland, the total amounts of Raise Slow (R60) and Raise Delayed (R5) services delivered by enabled plants is shown in Figure 2. 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 increasing the export to Victoria during the time of the frequency excursion in the Mainland. The Mainland frequency dropped to a minimum of 49.65 Hz which triggered some of the switched controllers to provide delayed FCAS in Mainland.

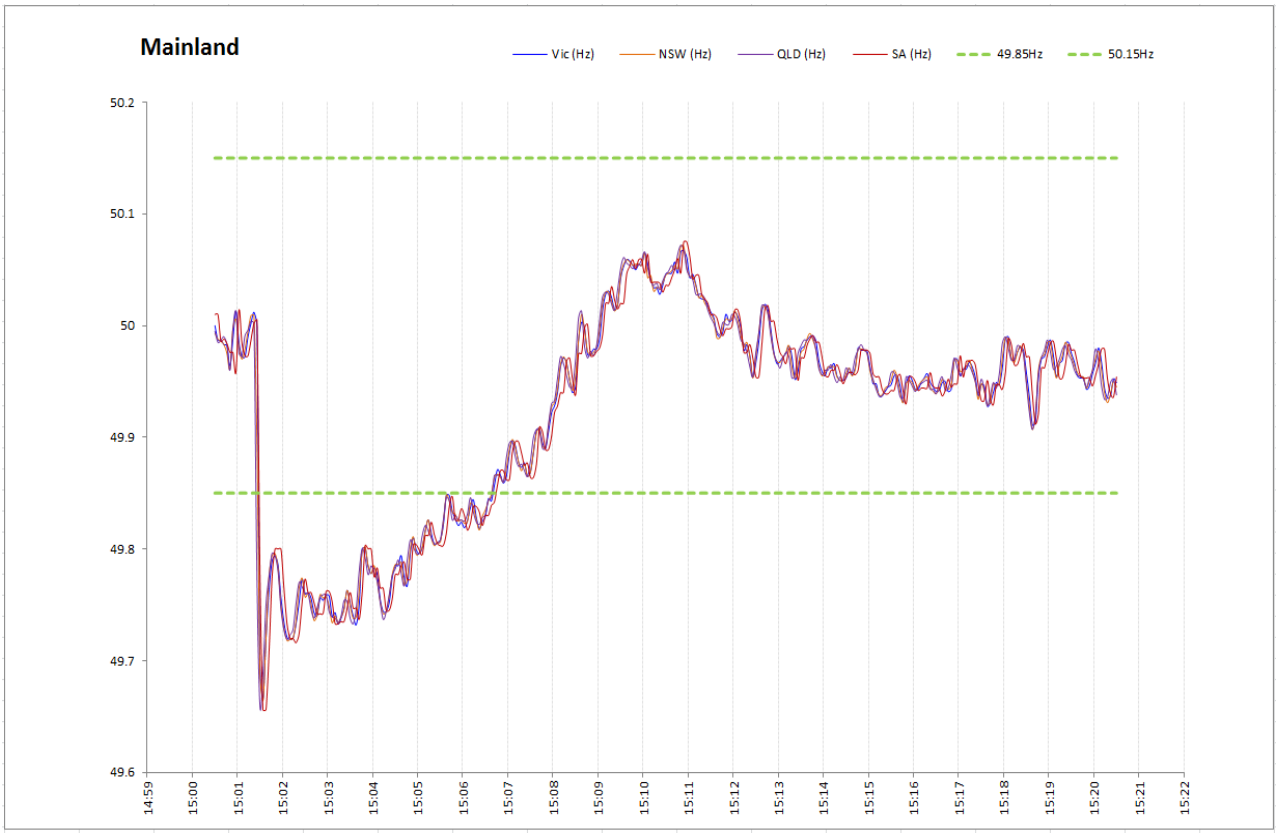

Figure 1: Mainland frequency during low frequency generation event in Table 2 on 04th November 2011.

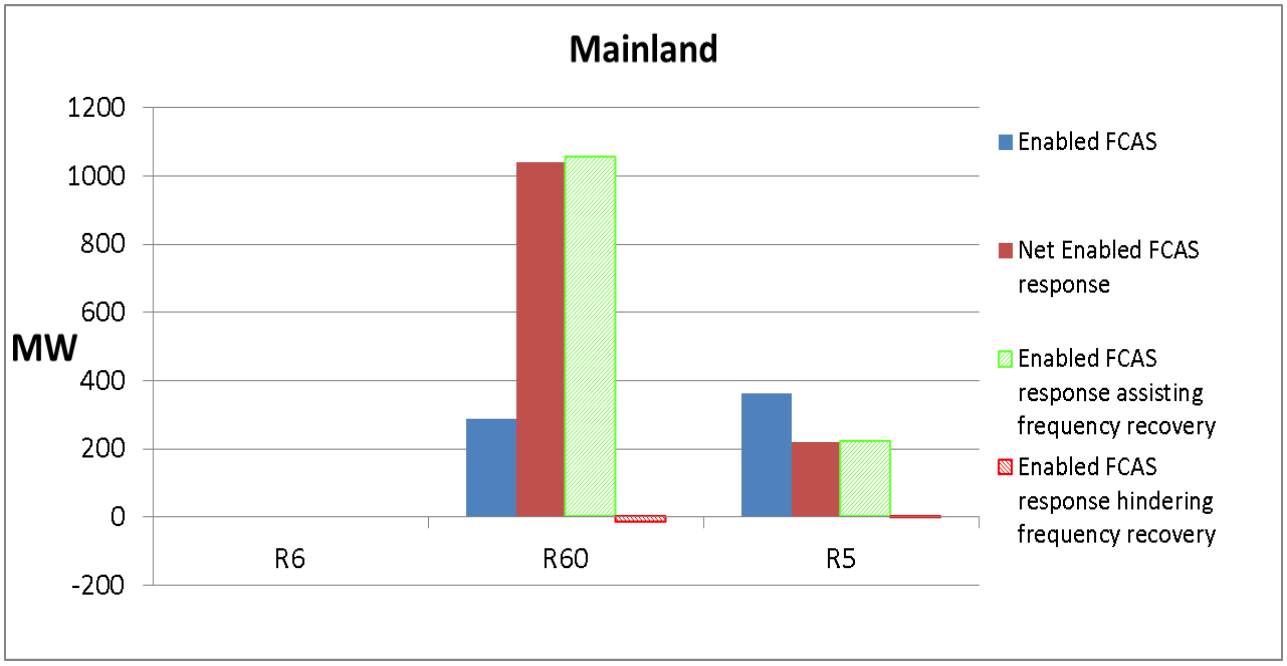

Figure 2: FCAS response to the Low Frequency Generation Event in the Mainland on 04 November 2011.

As a consequence of the low frequency generation event in the Mainland region, the Basslink frequency controller operated to provide FCAS service to Mainland. This resulted in causing a low frequency excursion in Tasmania. to provide FCAS service to the Mainland Frequency fell to a minimum of 49.07 Hz in the Tasmanian region as shown in Figure 3 below. This event is within the Tasmania Frequency Operating Standards since the Tasmania frequency recovered within 260 seconds, well within the Frequency Operating Standard of 600 secs for recovery.

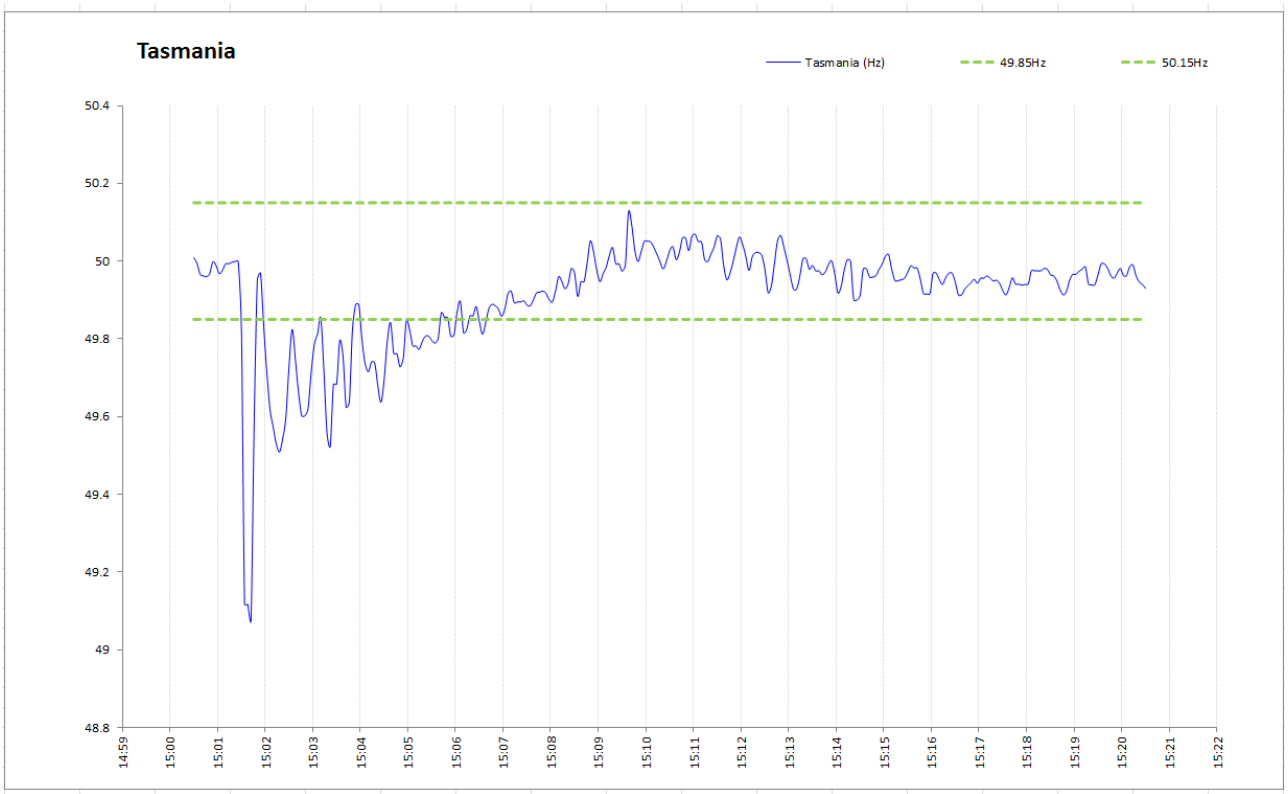

Figure 3: Tasmania frequency during low frequency generation event in Table 2 on 04th November 2011.

4.1.2 Generation Event: 07/11/2011 11:55:52

On 07 November 2011 at 1155 hrs, Loy Yang A Unit 2 tripped from 500 MW. This resulted in the power system frequency deviating below the lower limit of the Mainland Frequency Operating Standards for 316 seconds as shown in Figure 4. Loy Yang A2 was not enabled for raise FCAS.

In response to the low frequency generation event in Table 2 on 07 November 2011, the total amounts of Raise Slow and Raise Delayed services delivered by enabled plants are shown in Figure 5. 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 increasing the export to Victoria during the time of the frequency excursion in the Mainland. The Mainland frequency dropped to a minimum of 49.72 Hz which triggered some of the switched controllers to provide delayed FCAS in Mainland.

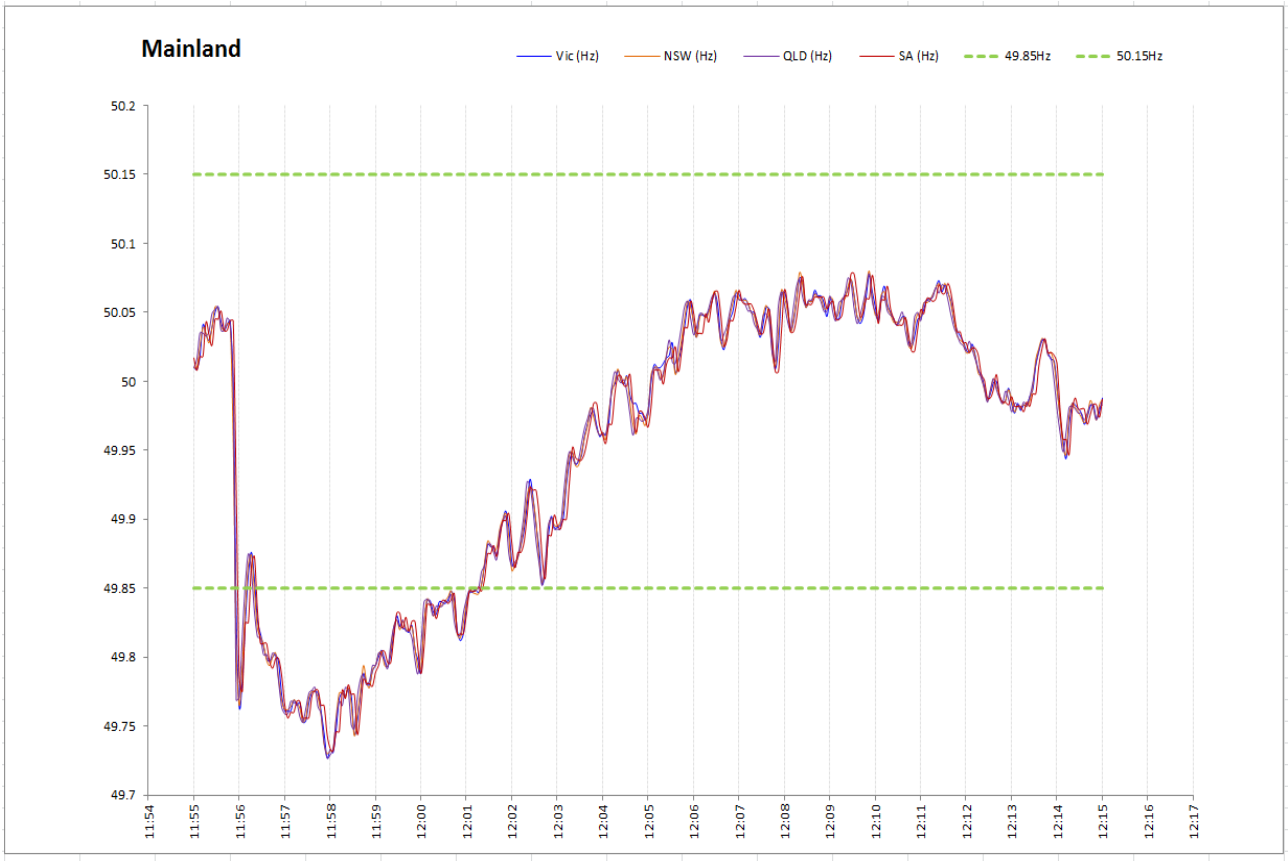

Figure 4: Mainland frequency during low frequency generation event in Table 2 on 07th November 2011.

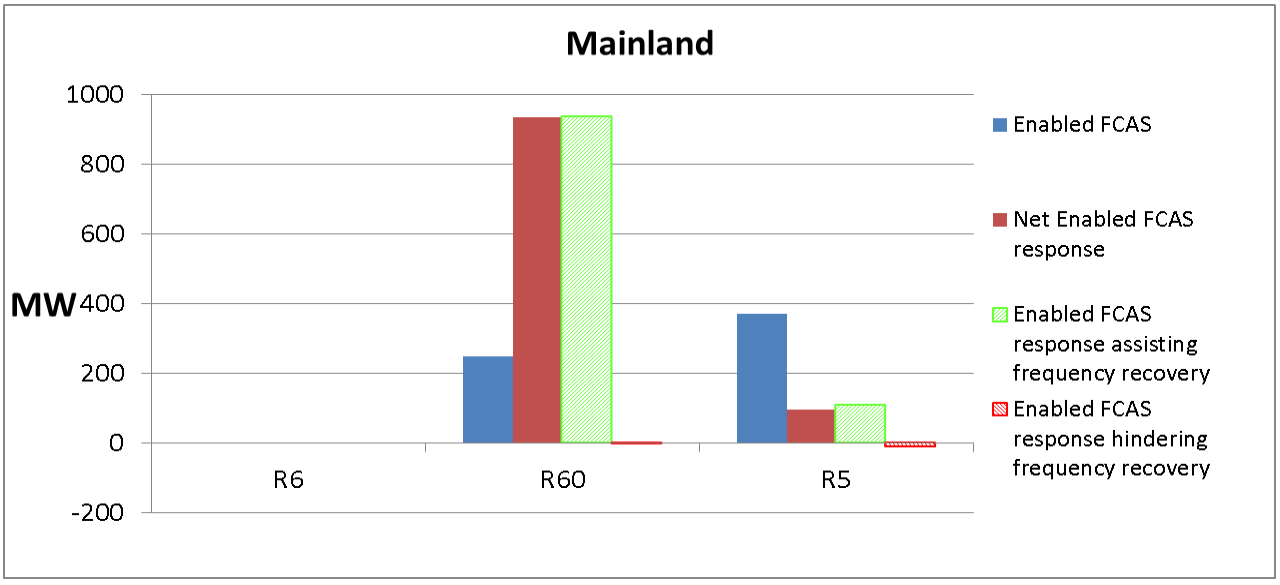

Figure 5: FCAS response to the Low Frequency Generation Event in the Mainland on 07 November 2011.

As a consequence of the low frequency generation event in the Mainland region, the Basslink frequency controller operated to provide FCAS service to Mainland. This resulted in causing a low frequency excursion Tasmania to provide FCAS service to the Mainland. Frequency fell to a minimum of 49.57 Hz in the Tasmanian region as shown in Figure 6 below. This event is within the Tasmania Frequency Operating Standards since the Tasmania frequency recovered within 284 seconds, well within the Frequency Operating Standard of 600 secs for recovery.

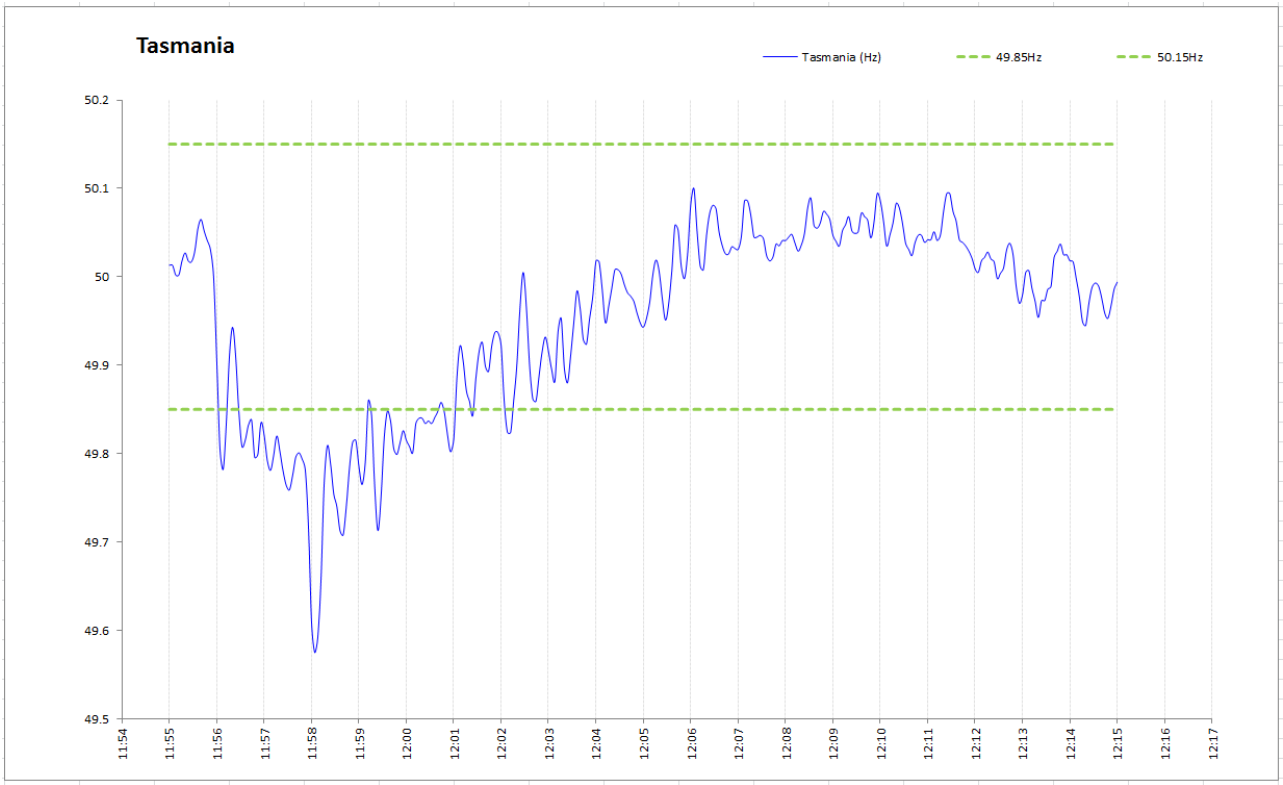

Figure 6: Tasmania frequency during low frequency generation event in Table 2 on 07^{tn} November 2011.

4.1.3 Generation Event: 29/11/2011 07:41:16

On 29 November 2011 at 0741 hrs, Newport generating unit tripped from 495 MW. This resulted in the power system frequency deviating below the lower limit of the Mainland Frequency Operating Standards for 396 seconds as shown in Figure 7. Newport was enabled for raise FCAS at the time of the event.

In response to the low frequency generation event in Table 2 on 29 November 2011, the total amounts of Raise Slow and Raise Delayed services delivered by enabled plants are shown in Figure 8. The net delivered R60 FCAS and 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 increasing the export to Victoria during the time of the frequency excursion in the Mainland. The Mainland frequency dropped to a minimum of 49.79 Hz which triggered some of the switched controllers to provide delayed FCAS in Mainland.

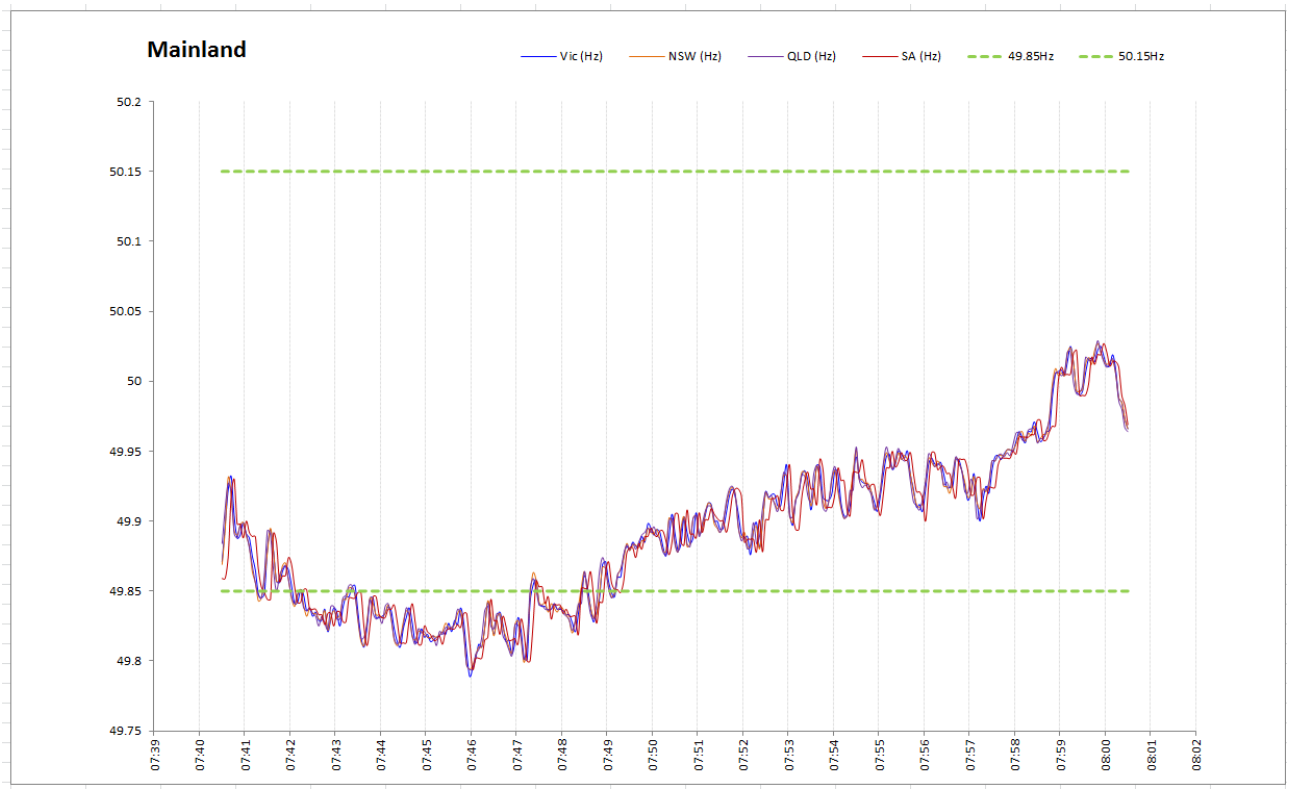

Figure 7: Mainland frequency during low frequency generation event in Table 2 on 29th November 2011

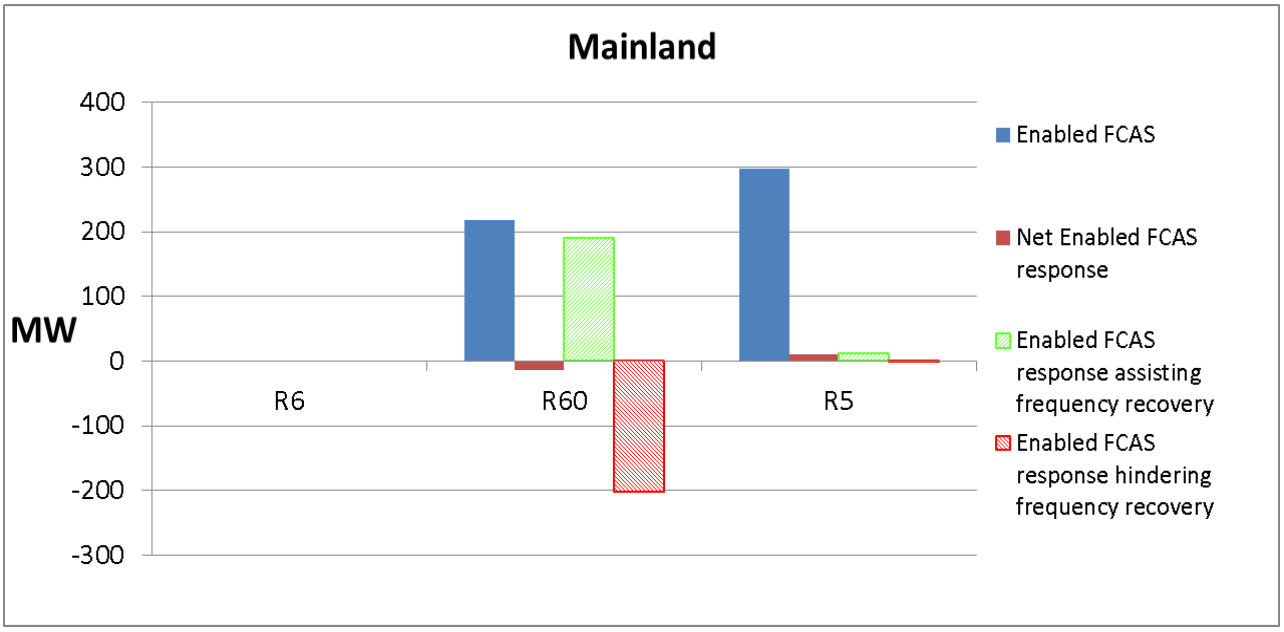

Figure 8: FCAS response to the Low Frequency Generation Event in the Mainland on 29 November 2011.

As a consequence of the low frequency generation event in the Mainland region, the Basslink frequency controller operated to provide FCAS service to Mainland. This resulted in causing a low frequency excursion in Tasmania to provide FCAS service to the Mainland. Frequency fell to a minimum of 49.79 Hz in the Tasmanian region as shown in Figure 9 below. This event is within the Tasmania Frequency Operating Standards since the Tasmania frequency recovered within 260 seconds, well within the Frequency Operating Standard of 600 secs for recovery.

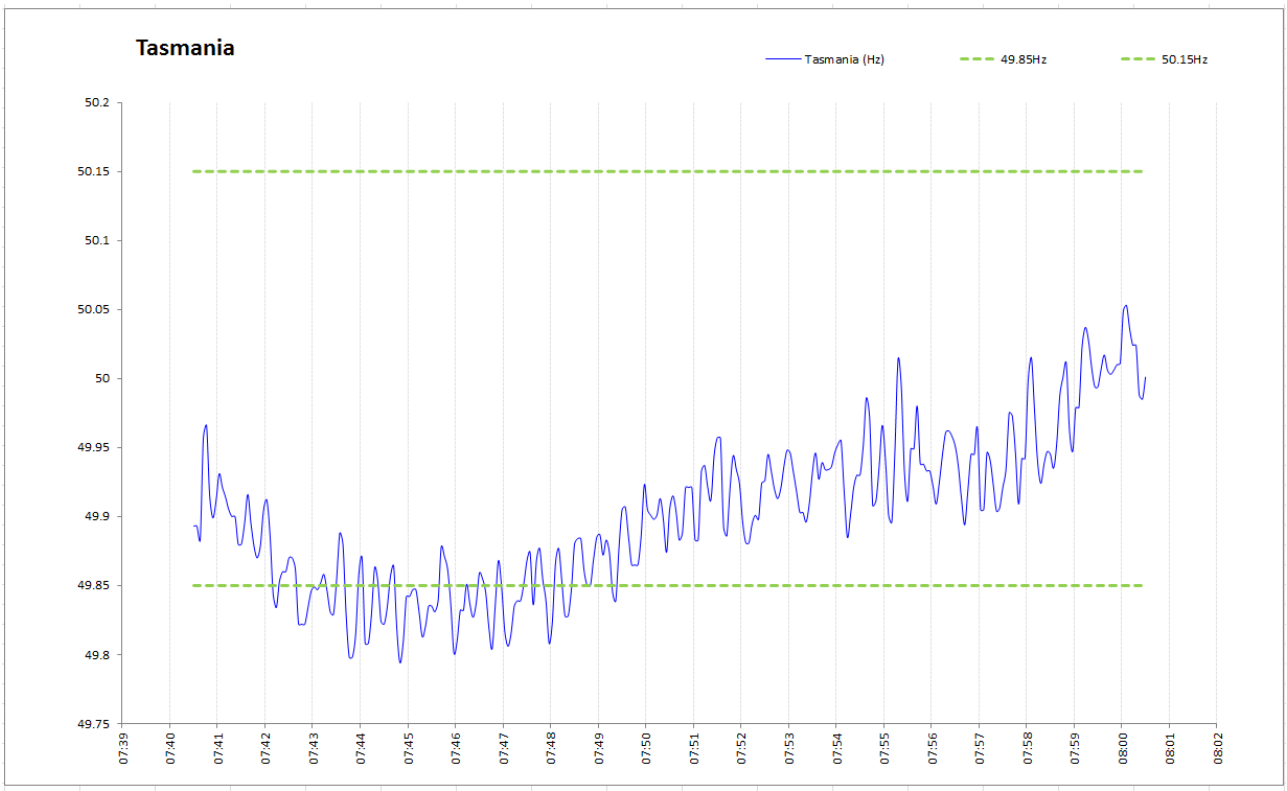

Figure 9: Tasmania frequency during low frequency generation event in Table 2 on 29th November 2011.

4.2 High Frequency Events in Tasmania

There was one High Frequency No Contingency event from Table 1 recorded in the Tasmania region during November 2011, that resulted in frequency above the threshold frequency of 50.25 Hz. This event did not meet the Tasmania Frequency Operating Standards and is listed in Table 3.

Table 3: High frequency No contingency Events in the Tasmania region that did not meet the Tasmania Frequency Operating Standards in November 2011.

DATE	EVENT	MAX FREQUENCY (HZ)	BELOW 49.85 HZ OR ABOVE 50.15 HZ FOR (SECONDS)
11/11/2011 14:00:32	No condition causing the event was identified.	50.29 Hz	8 seconds

4.2.1 Event: 11/11/2011 14:00:32

For the Normal (Non-Contingency) high frequency event on 11th November 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 major load in Tasmania reduced load by 50 MW resulting in a sudden spike in frequency to 50.29 Hz in Tasmania. Compared to the enabled Slow Lower (L60) and Delayed Lower (L5) FCAS, a zero amount was delivered as shown in Figure 11. Basslink provided frequency control by reducing import from Victoria to Tasmania. The amount of Fast Lower services delivered was not calculated since 50 ms data was not requested for this event.

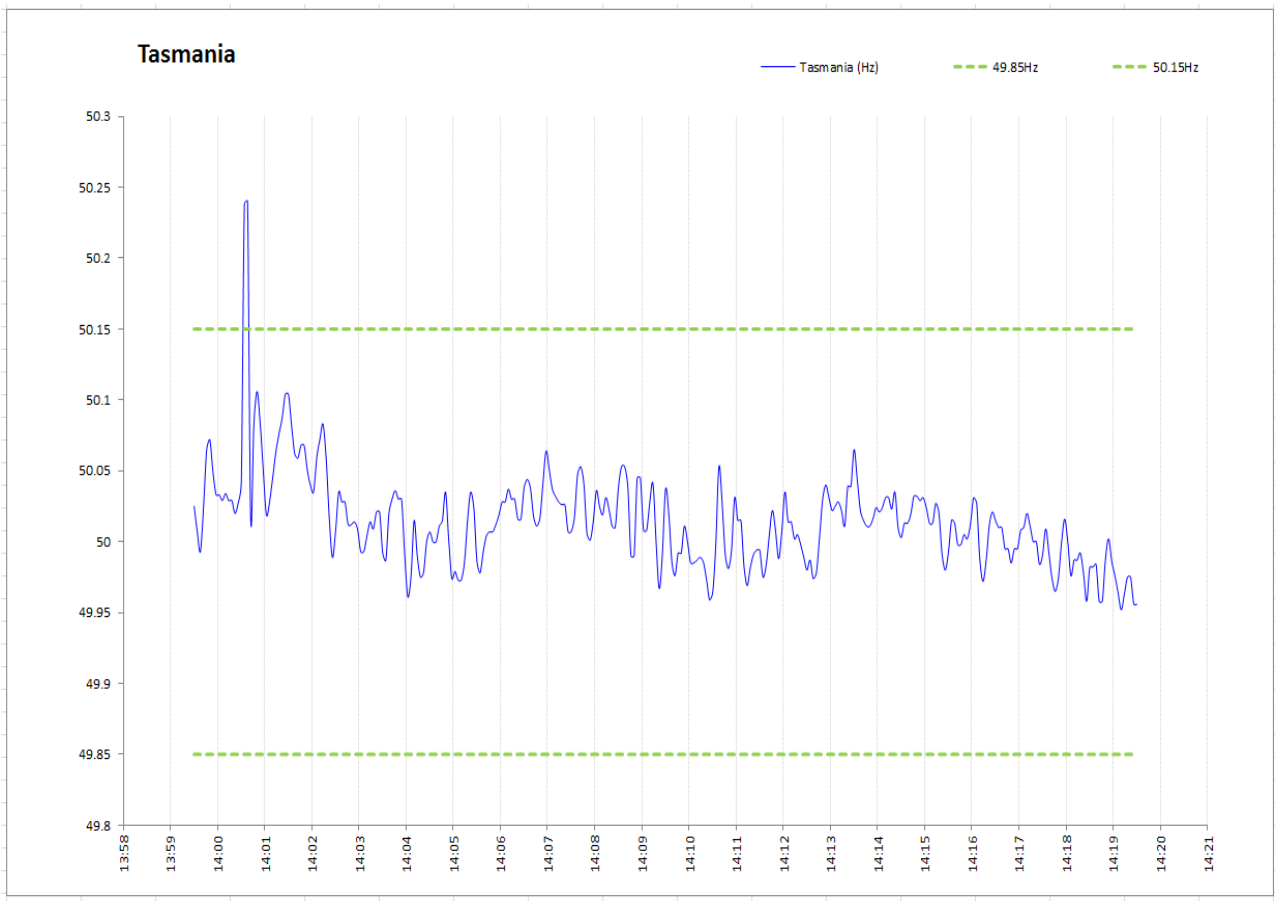

Figure 10: Tasmania frequency during High frequency No contingency event in Table 3 on 11th November 2011.

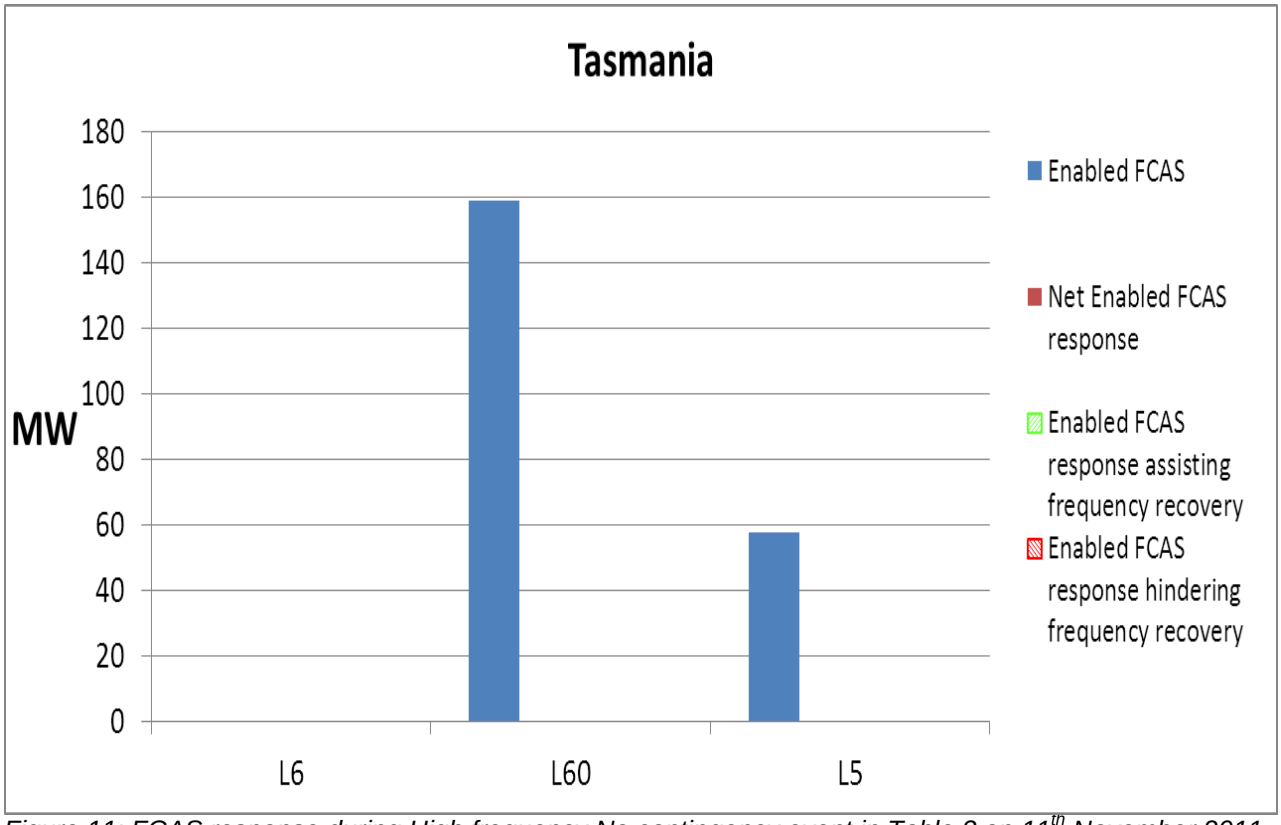

Figure 11: FCAS response during High frequency No contingency event in Table 3 on 11th November 2011

5 Statistical analysis

With exception of major power system disturbances which are excluded, the frequency distribution for the Mainland and Tasmanian regions were within the frequency operating standards in the month of November 2011.

Frequency in the Mainland regions was within the range 49.91 to 50.08 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 November 2011 was 50 Hz with a standard deviation of 0.032 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 100 % of the time. The mean value of frequency during November 2011 was 50 Hz with a standard deviation of 0.038 Hz.

5.1.1 Daily frequency standard deviation

Figure 12 and Figure 13 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.

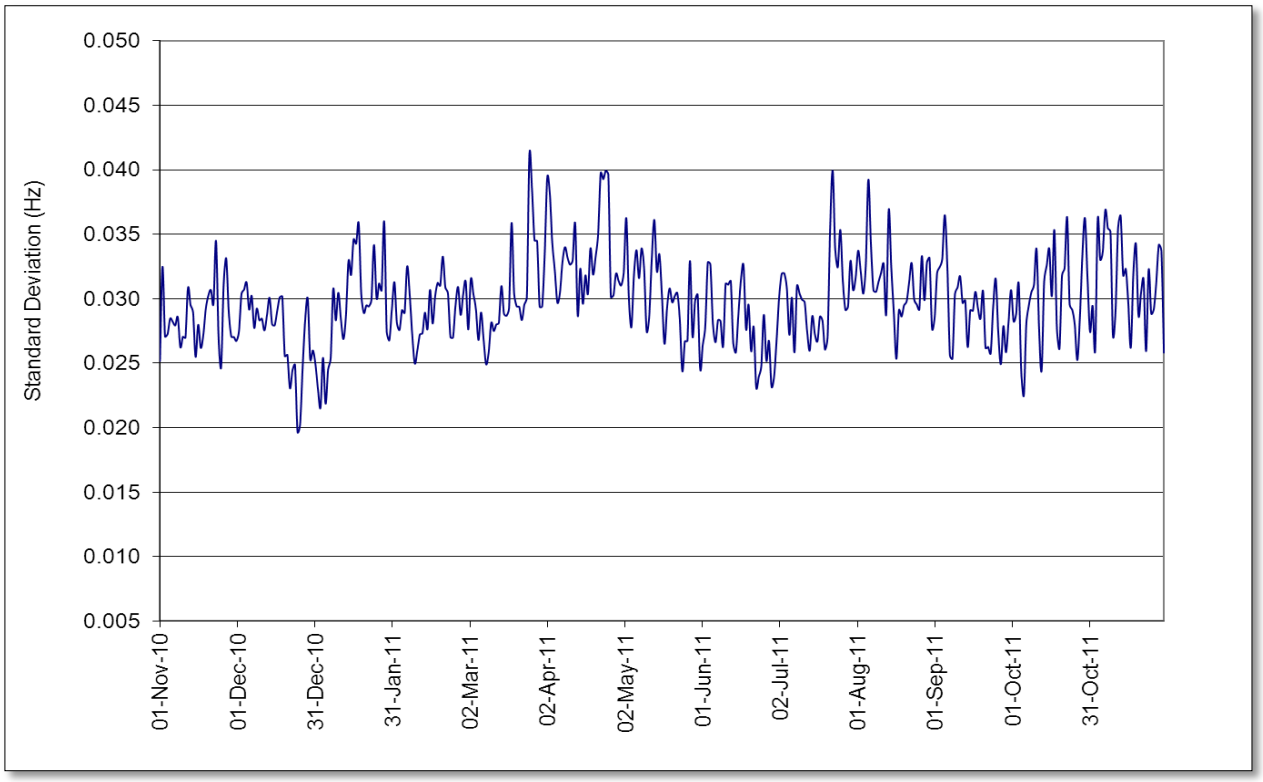

Figure 12: Daily standard deviation of frequency in Mainland.

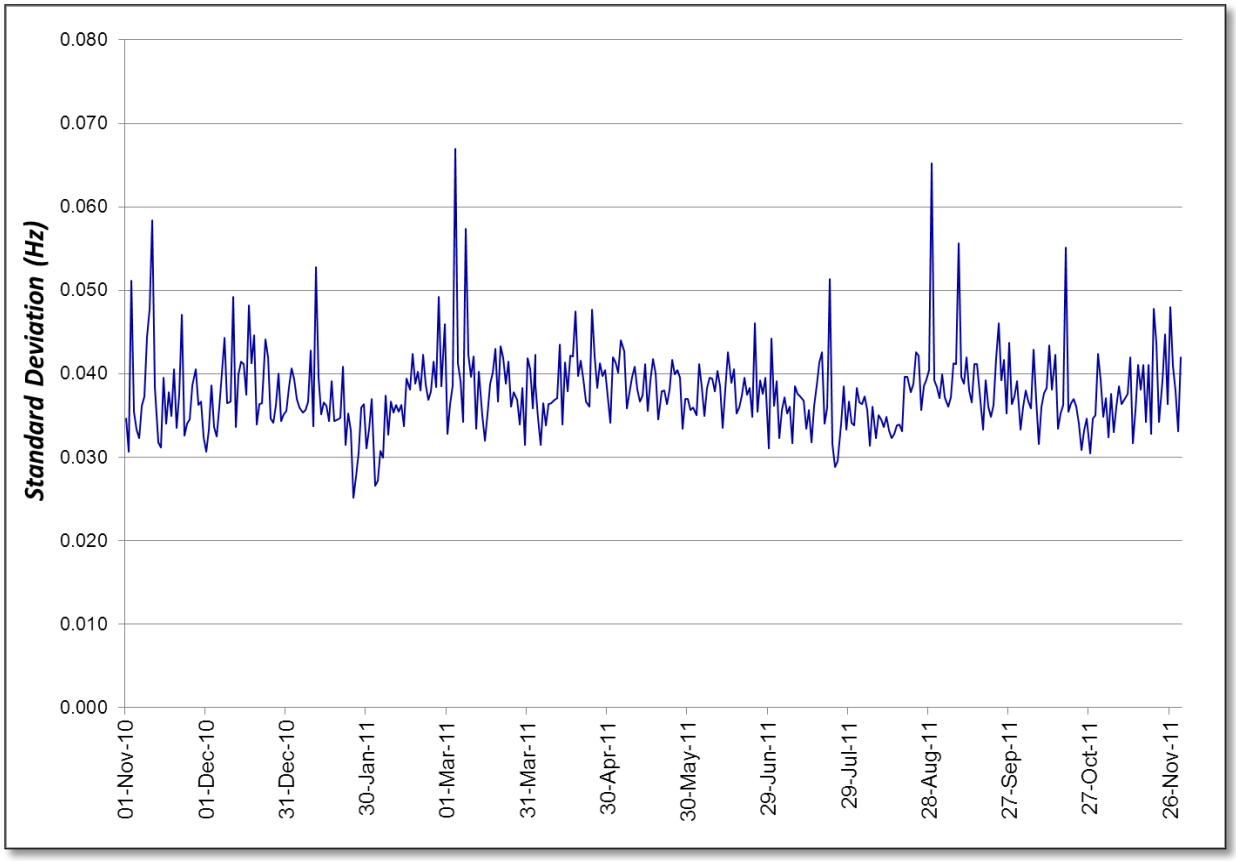

Figure 13: Daily standard deviation of frequency in Tasmania.

5.1.2 Time of day analysis

This section details the standard deviation of system frequency on a monthly and daily basis. Figure 14 and Figure 15 show the average half-hourly standard deviation of the Mainland regions and Tasmania frequency for September, October and November 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 14 and Figure 15 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).

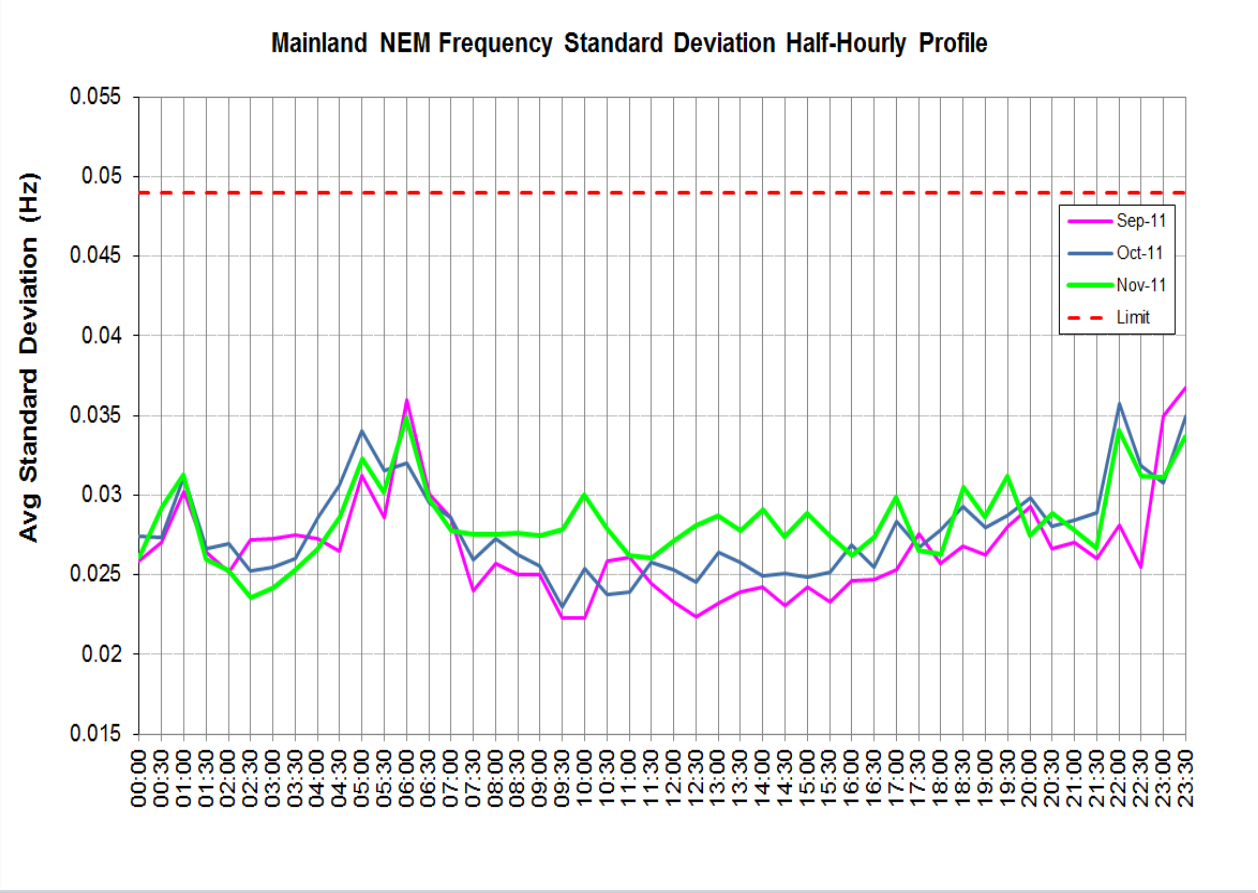

Figure 14: Daily profile of standard deviation for the frequency in the Mainland regions.

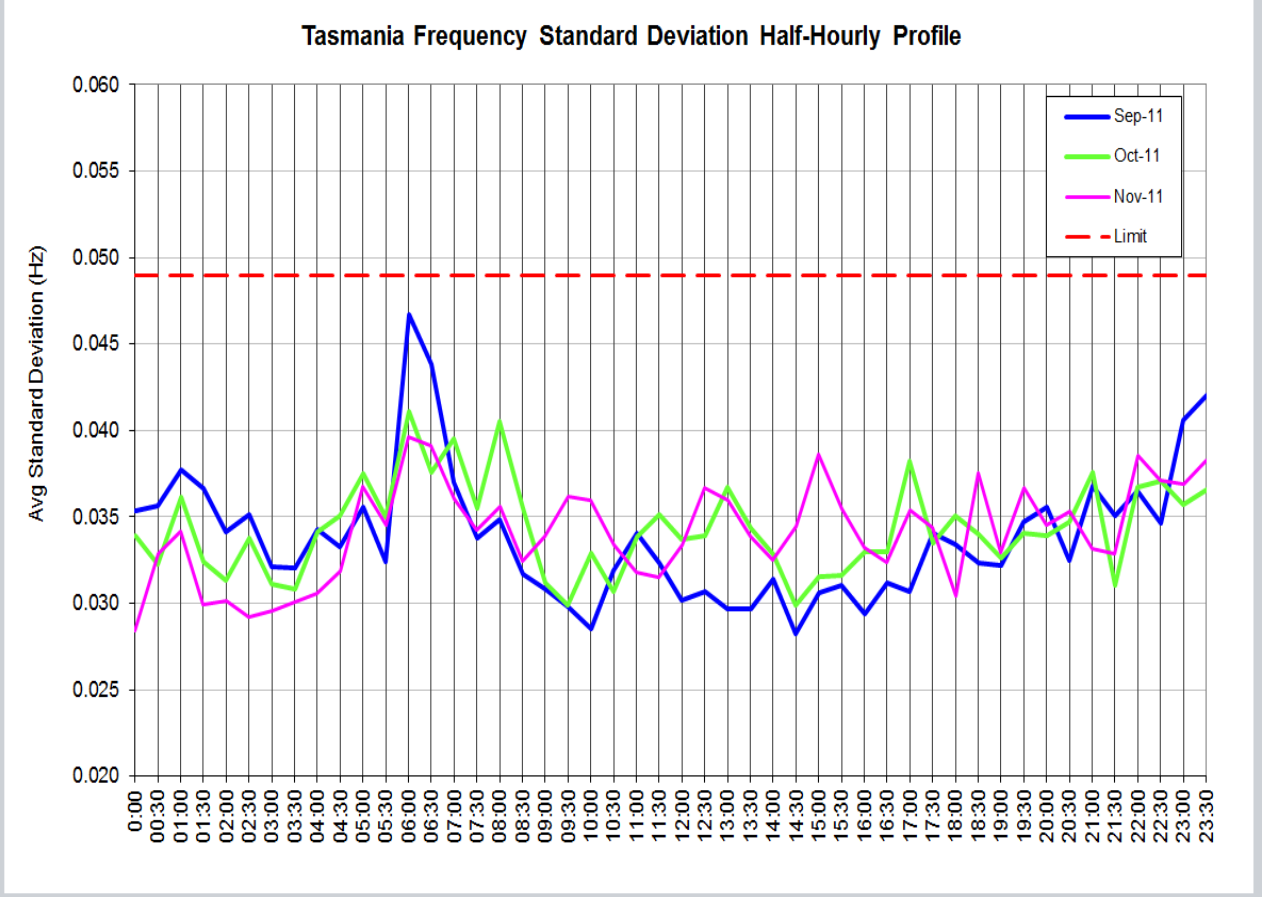

Figure 15: Daily profile of standard deviation for the frequency in Tasmania.

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 November 2011 is provided in Table 4.

Table 4: Accumulated time deviation statistics.

	QUEENSLAND	NSW	VIC	SA	TAS
Maximum Positive Deviation (s)	**5.36**[3]	**2.40**	**2.05**	**1.77**	**7.02**
Maximum Negative Deviation (s)	**-4.84**	**-4.75**	**-5.06**[4]	**-5.33**[5]	**-9.96**
Mean Value (s)	**-0.017**	**0.012**	**-0.347**	**-0.593**	**0.064**
Standard Dev (s)	**0.802**	**0.781**	**0.835**	**0.781**	**2.732**

The distribution of time deviations based on the Mainland regions measurement is provided in Figure 16.

[3] The accumulated time deviation in QLD exceeded +5.0 on 13/11/2011 20:23 hrs due to a separation event when QLD separated from the rest of the mainland.
[4] The accumulated time deviation in VIC exceeded -5.0 on 08/11/2011 11:58 hrs when two major generating units in NSW had to be taken out of service resulting in increased interconnector flow across the VIC-NSW interconnector.
[5] The accumulated time deviation in SA exceeded -5.0 on 08/11/2011 11:58 hrs when two major generating units in NSW had to be taken out of service resulting in increased interconnector flow across the VIC-SA and VIC-NSW interconnectors.

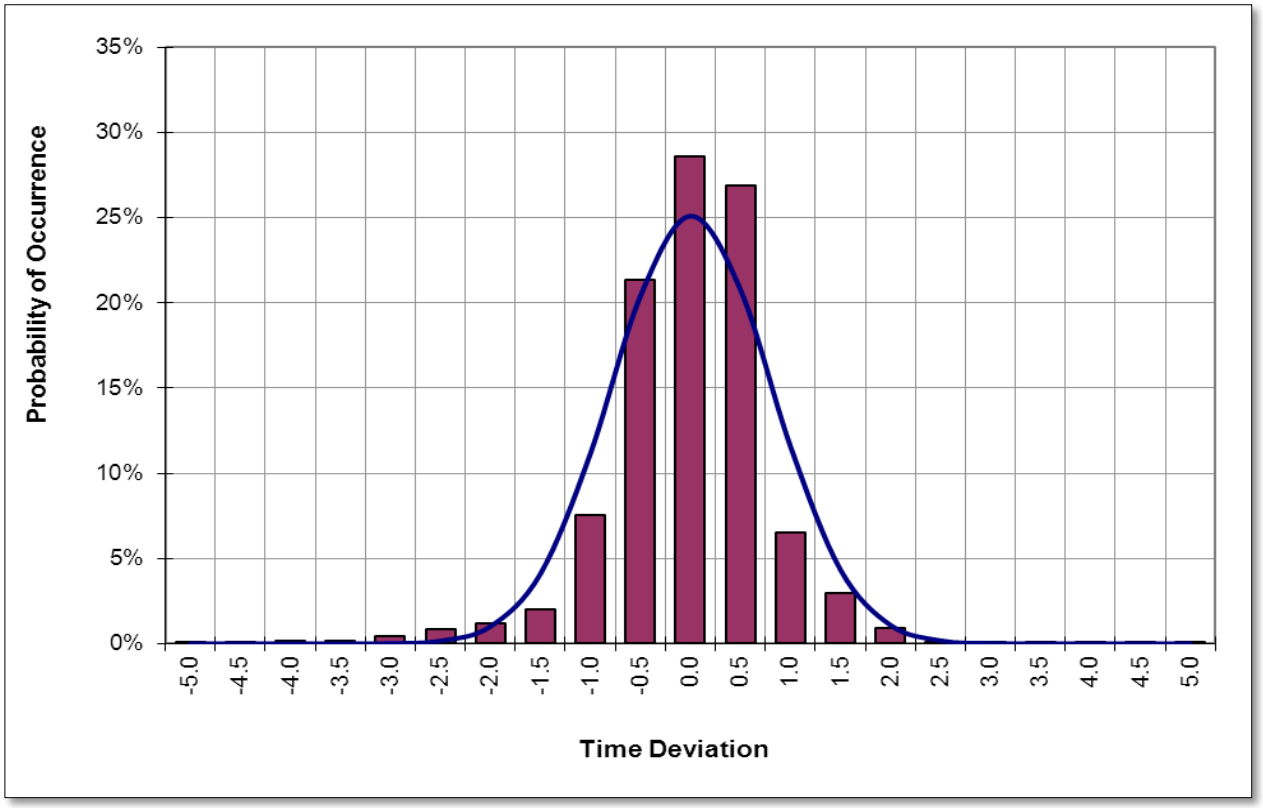

Figure 16: Mainland time deviation distribution for November 2011

The distribution of time deviations based on the Tasmania region measurement is provided below in Figure 17.

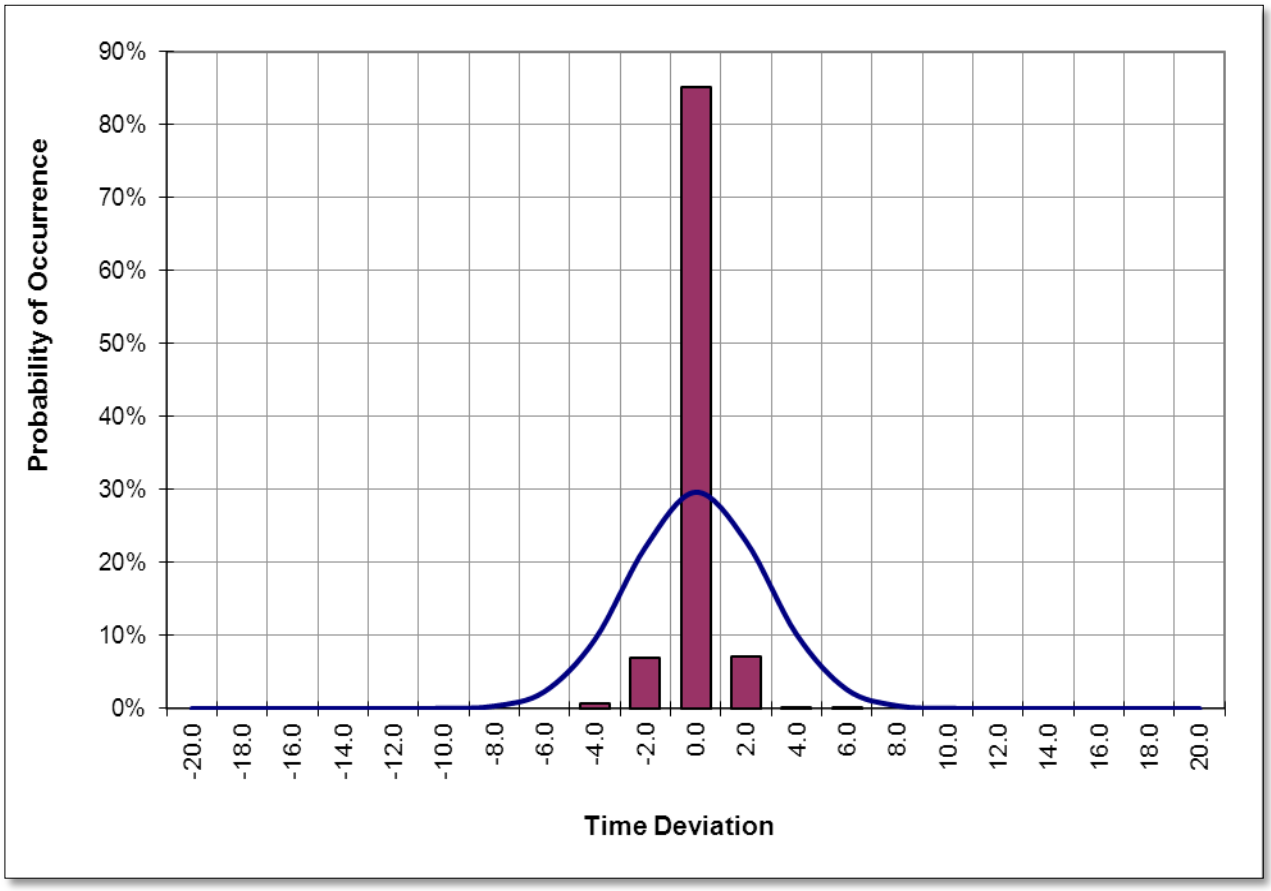

Figure 17: Tasmania time deviation distribution for November 2011

6.1 Time error performance

Figure 18 below presents the daily maximum and minimum values of the Mainland regions time error observed for the past 13 months.

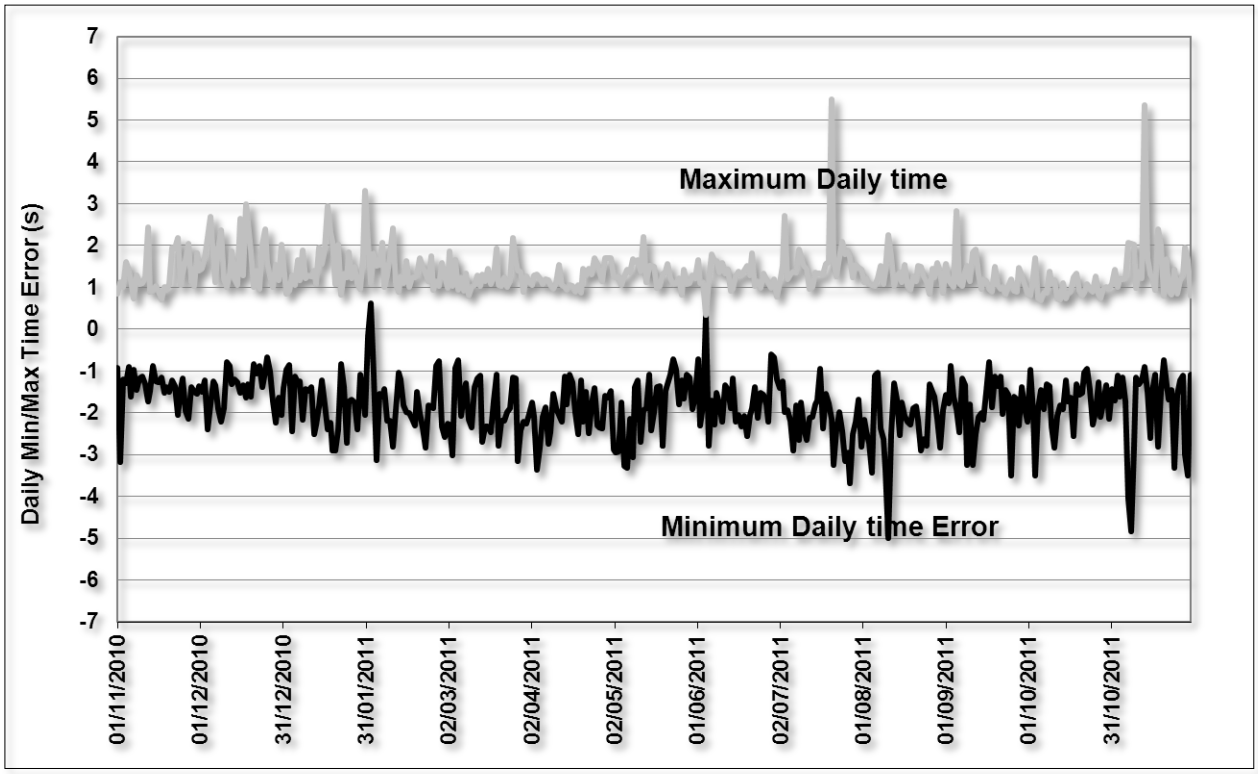

Figure 18: Mainland regions daily maximum and minimum time deviation.

Figure 19 presents the daily maximum and minimum values of Tasmania time error observed for the past 13 months.

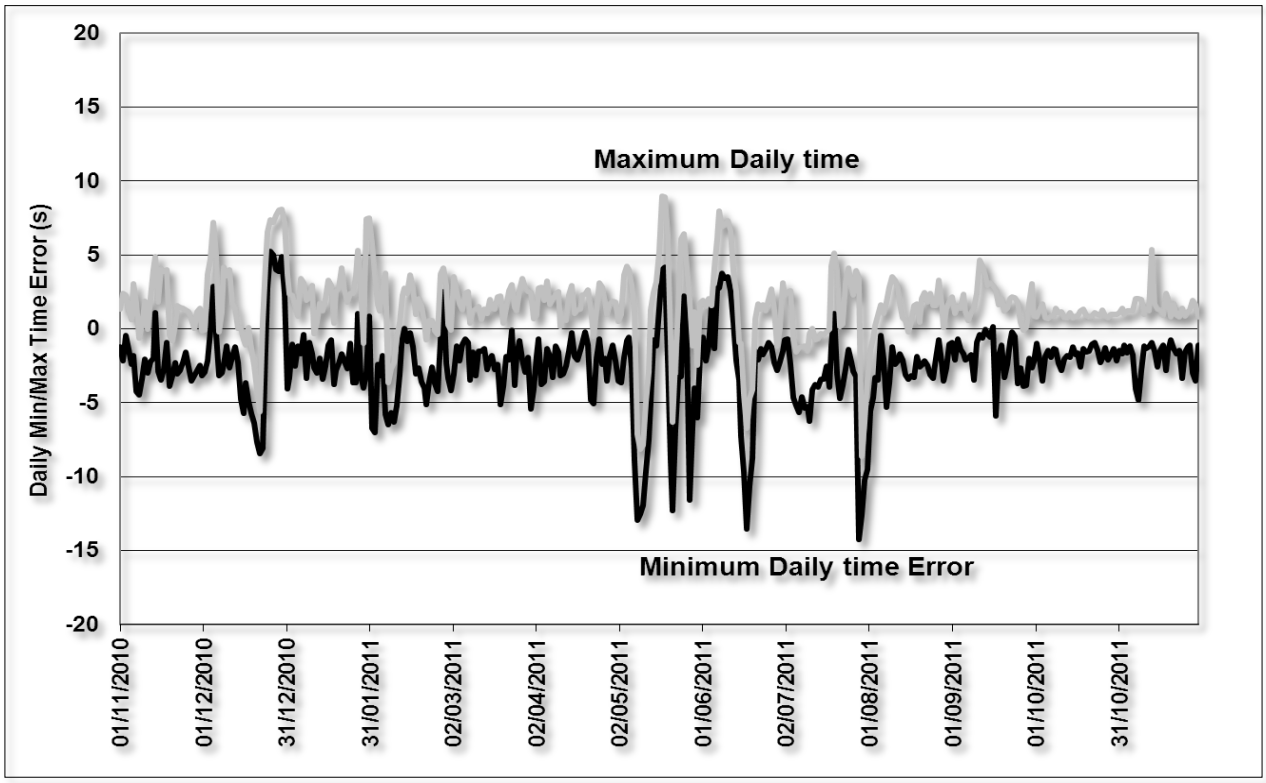

Figure 19: Tasmania daily maximum and minimum time deviation.