DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – JUNE 2023

Transpower New Zealand Limited

June 2023

Keeping the energy flowing

TRANSPOWER

Transpower New Zealand Limited The National Grid

NOTICE

Version	Date	Change
1.0	18/03/2024	Final

	Position	Date
Prepared By:	Jessie Fahey, Power Systems Engineer	22/02/2024
Reviewed By:	Richard Sherry, Principal Engineer	18/03/2024

Contents

1 Executive summary

1.1 Purpose

The low frequency dynamic oscillatory stability of the power system has been analyzed using phasor measurement unit data for the month of June 2023. This monthly report presents these findings for June 2023 and follows the same methodology as other monthly reports. Together these reports can be used to track significant changes over time specifically aimed at drawing attention to changes of oscillation behavior.

If some oscillation modes have changed significantly, a more detailed investigation should be required to identify the cause (e.g. load growth, generator, controller, topology, etc.)

1.2 Objectives

This monthly report's objective is to highlight significant modes on the network to help continuously assess the changes of the modes over time and changes in system conditions in order to trigger more detailed investigations in case of poor damping events.

2 Current status and observations

Mode freq.	Signal	Comments	Observations in June 2023
0.04 Hz	All-f	Governor modes	No significant change over the month Well-damped
0.25 Hz	All-f All-p	Probably control modes, and not electro-mechanical	Relatively high number of occurrences Occurrences of low damping periods
0.5 Hz	All-f All-p	Forced oscillation, possibly interarea modes in addition	High decay time Relatively low amplitude
0.9-1 Hz	All-f Most-p BPE-p	Inter-area and Inter-station modes	High decay time Relatively low amplitude
1.7-1.9 Hz	All-f All-p	Inter-station and Local modes, including forced oscillations	High number of occurrences Periods of relatively high amplitude
2.4-2.5 Hz	Most-f Most-p	Not yet identified	Low number of occurrences Well damped

The Wairakei PMU was disconnected from the start of 2023 through to 5th October.

3 Detailed plots for June 2023

3.1 Mode frequency histograms

Remark: the frequency histograms are shown for a frequency range [0.04 4Hz]

3.1.1 PMU Frequency Data

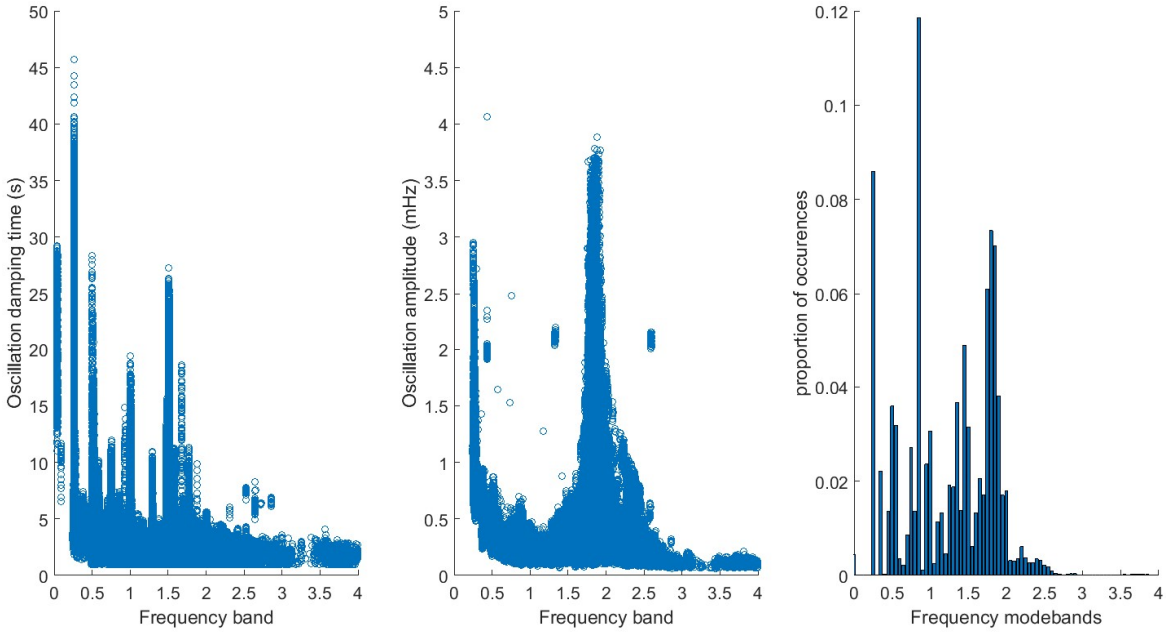


Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

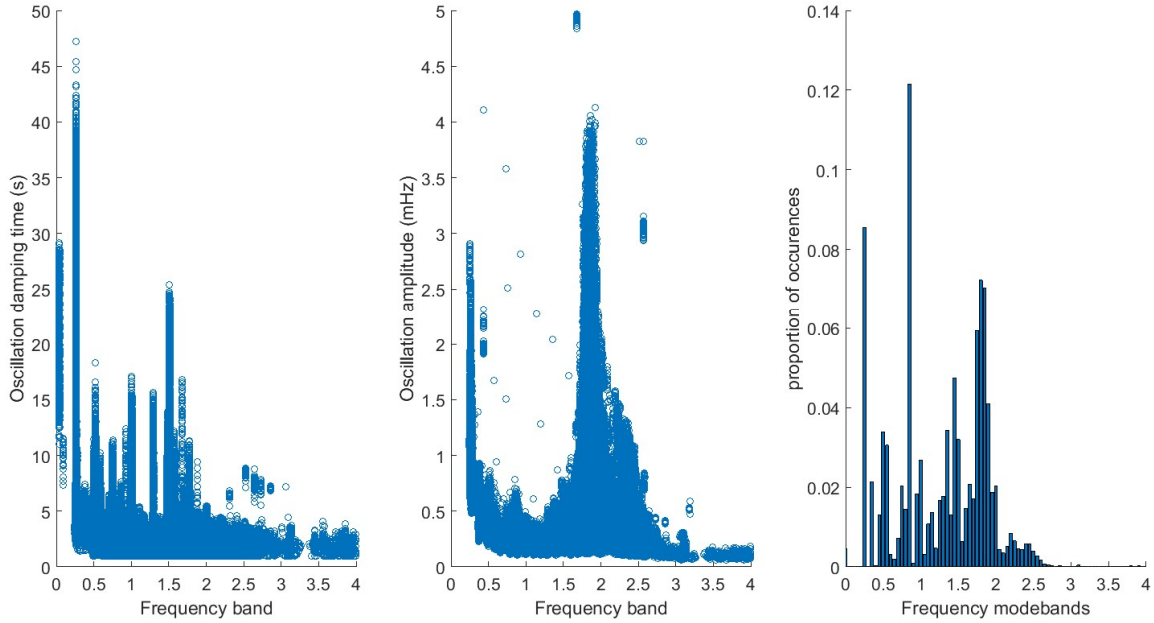


Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

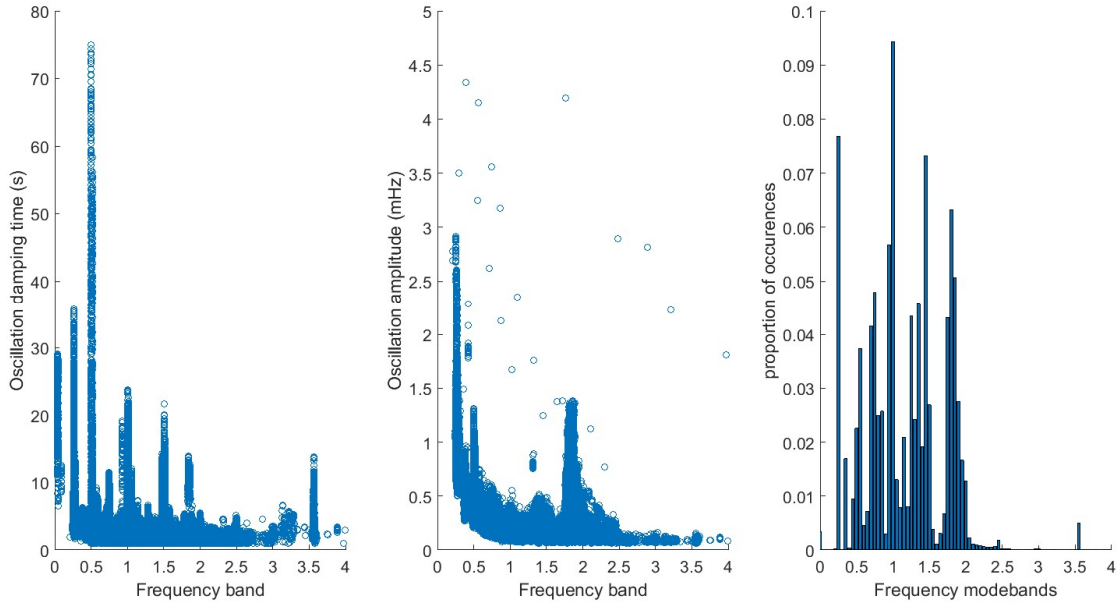


Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

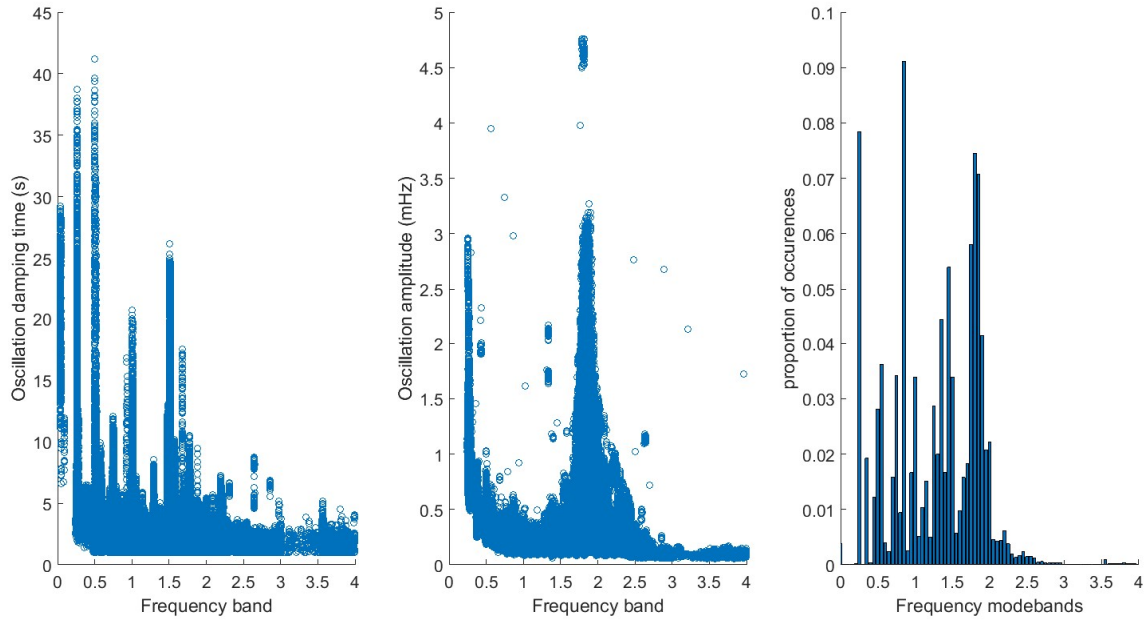


Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

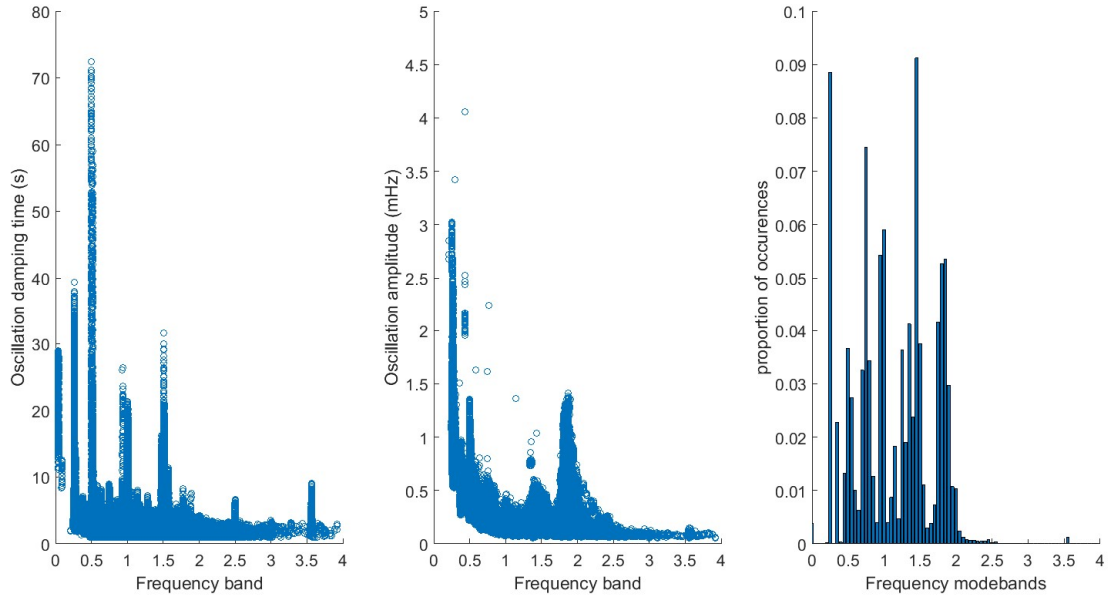


Figure 5: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

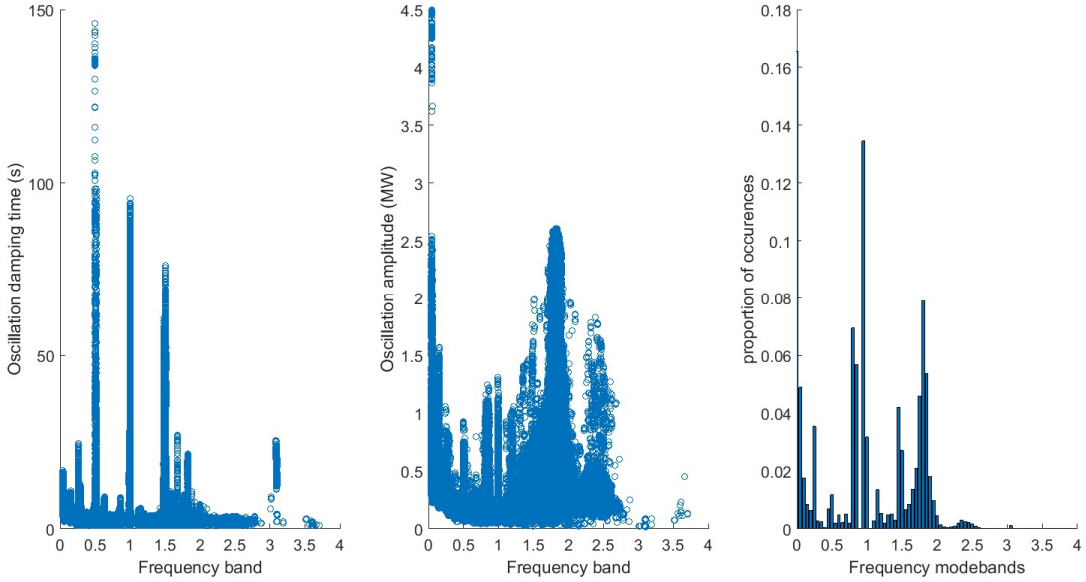


Figure 6: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

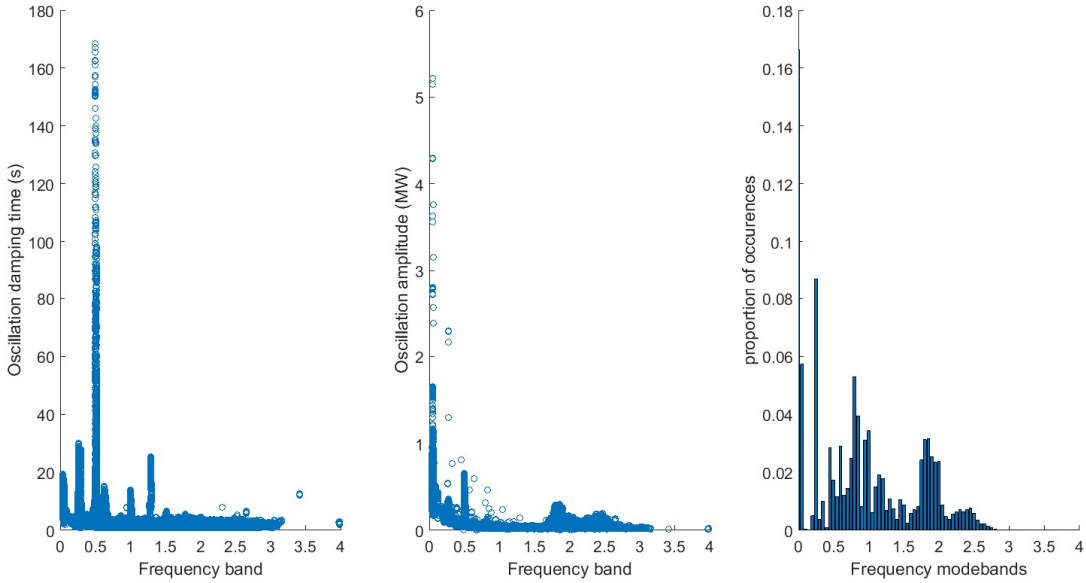


Figure 7: Haywards mode damping, mode amplitude, and frequency histogram using active power data

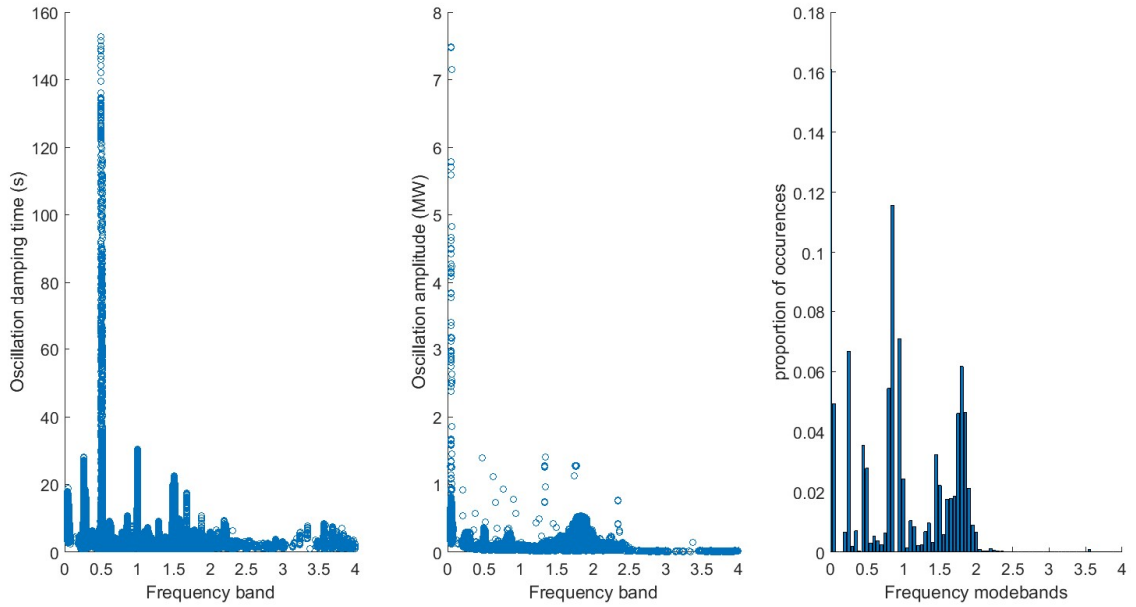


Figure 8: Huntly mode damping, mode amplitude, and frequency histogram using active power data

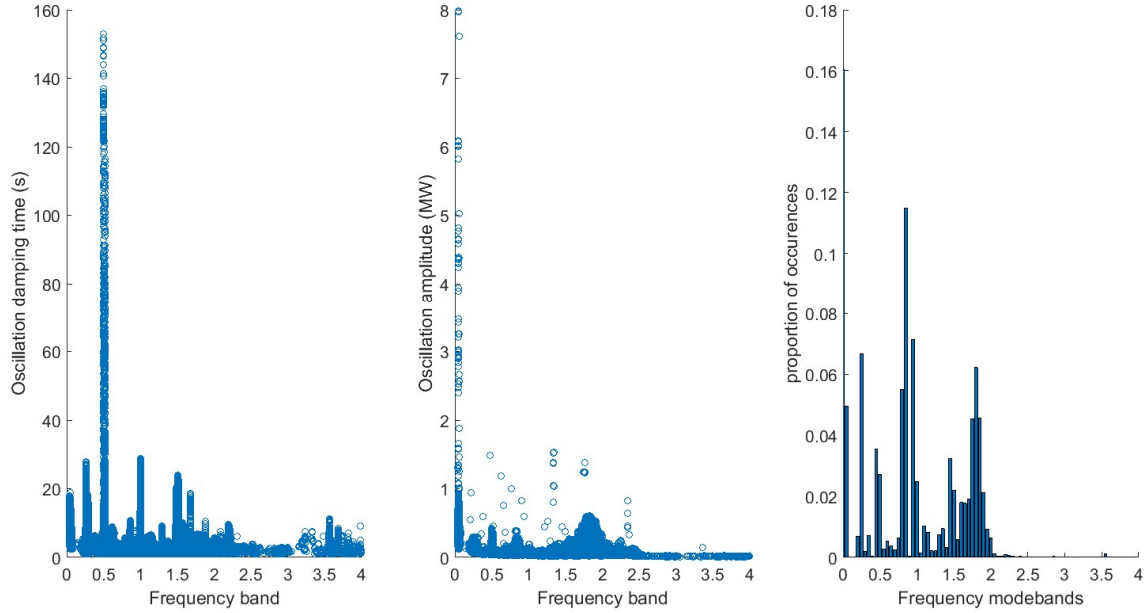


Figure 9: Stratford mode damping, mode amplitude, and frequency histogram using active power data

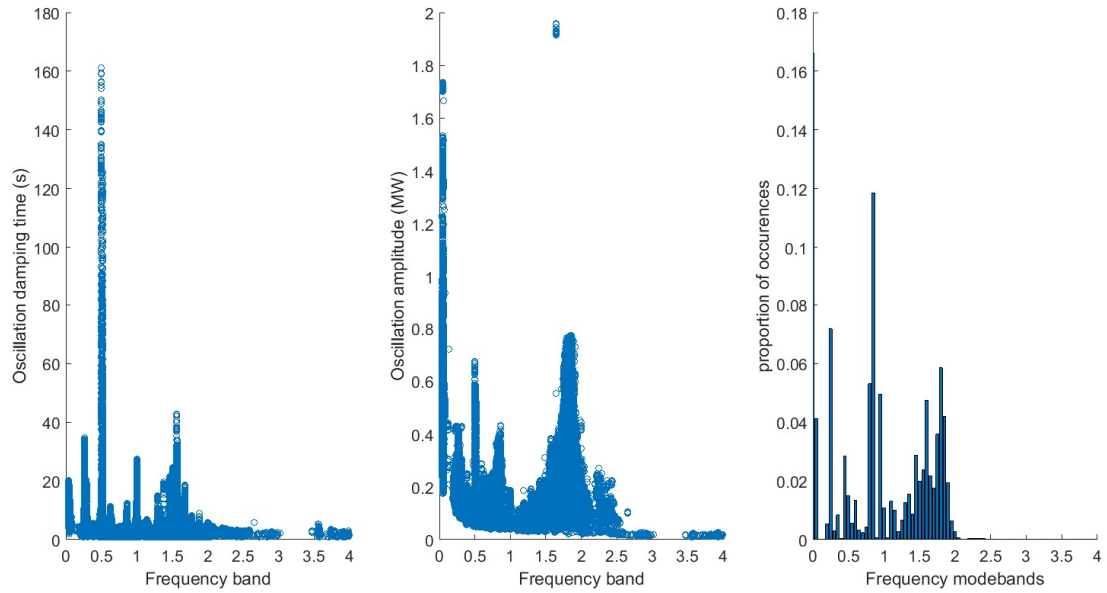


Figure 10: Whakamaru mode damping, amplitude, and frequency histogram using active power data

3.1.3 Observations using the frequency histograms

From the histograms, it can be observed that some modes have a large percentage of occurrences.

One new observation is very poor damping being observed for a 0.5 Hz mode. A distinct mode at approximately 1.8 Hz can also be observed in the June data.

The frequency histograms usually do not contain enough information to precisely define all modes of interest however, the following approximate modes are observed from the data:

- 0.25 Hz
- 0.5 Hz
- 1 Hz
- 1.5 Hz
- 1.8 Hz
- 2.5 Hz

The mode at 0.5 Hz had a high damping time up to 160 seconds due to an event near the end of the month. However, its amplitude was relatively low at the mHz range in the frequency data, and less than 1MW in the power data.

The oscillation was found to originate from the South Island and be most observable at the Tiwai substation - on the 30th June the signal at Tiwai (8 MW peak to peak) compared to the signal at Whakamaru (less than 2 MW peak to peak) is shown in Figure 11 below.

This behaviour is being investigated further.

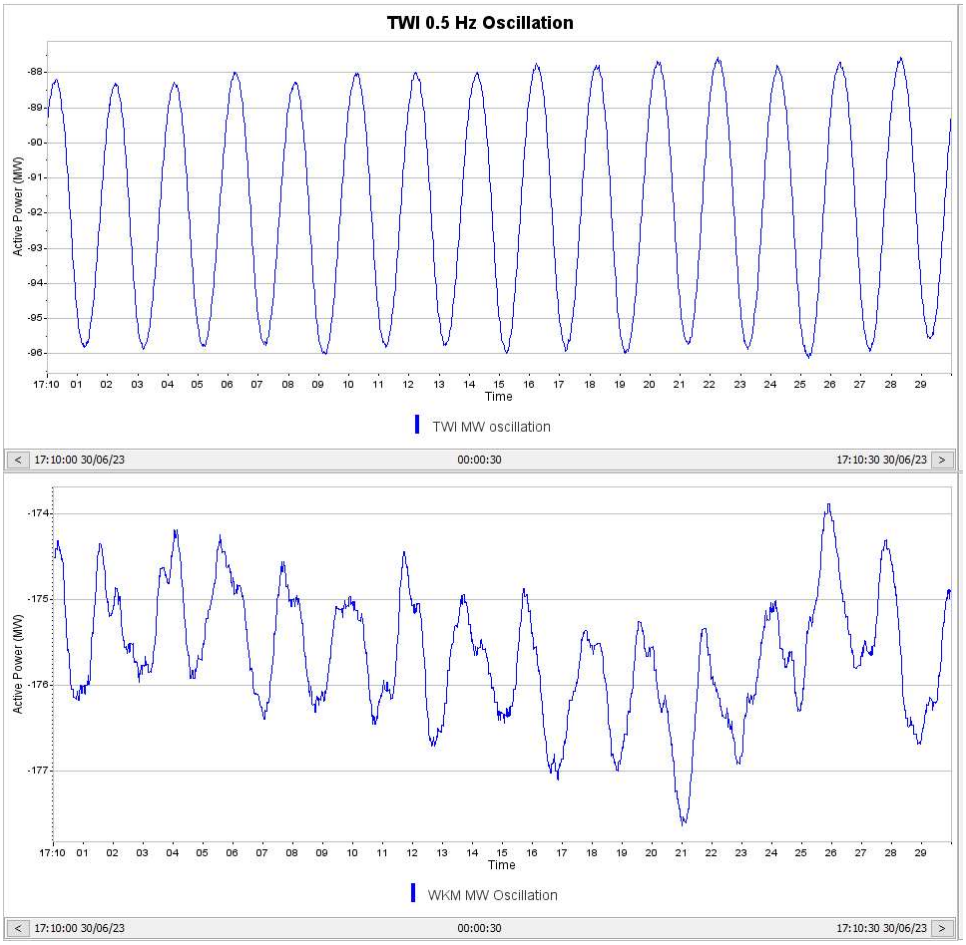


Figure 11: TWI and WKM PMU Active Power (MW) recording for the June 0.5 Hz mode

3.2 Defining mode bands

Mode bands are used to separate the different oscillating modes. Nevertheless, using the mode frequency is not a restrictive enough criterion to separate modes. Hence, several modes can still coexist in the same frequency band.

The following mode bands are defined:

0.0-0.2 Hz	0.2-0.6 Hz	0.6-0.9 Hz	0.9-1.2 Hz	1.2-1.8 Hz	1.8-2.4 Hz	2.4-4 Hz

3.3 Mode band 1: [0.0 – 0.2 Hz]

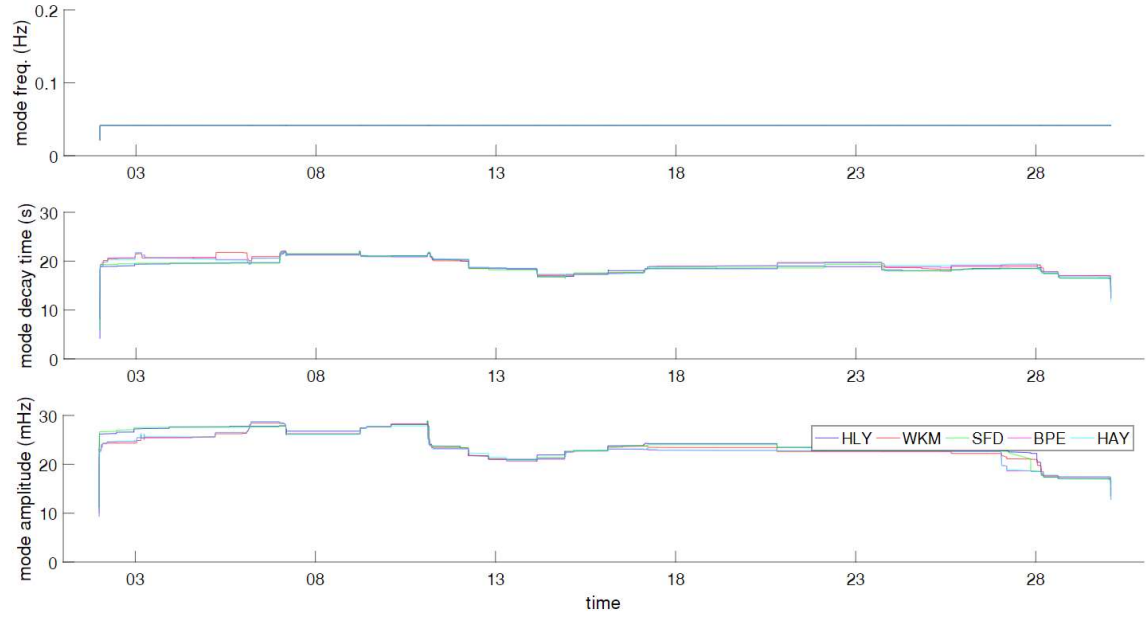


Figure 12: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

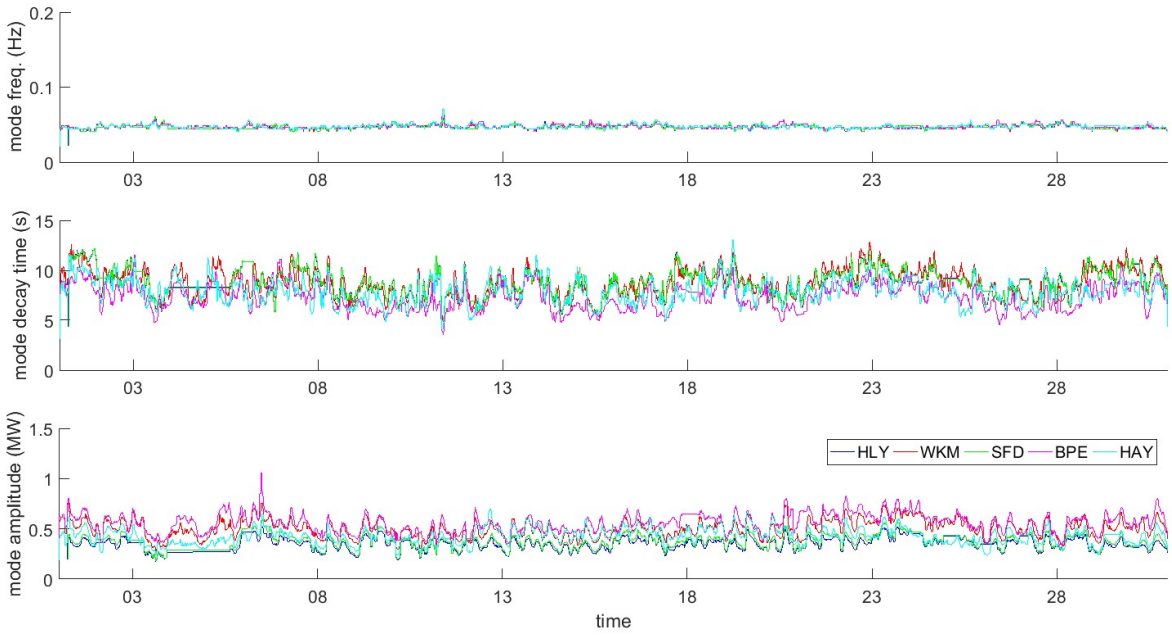


Figure 13: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

Using PMU frequency

- 0.04 Hz (governor) mode observed.
- For these persistent very low frequency modes the envelope decay times reported by the software are misleadingly short.

Using active power:

- 0.04-0.06 Hz mode observed.

- Maximum amplitude ~1 MW.

3.4 Mode band 2: [0.2 – 0.6 Hz]

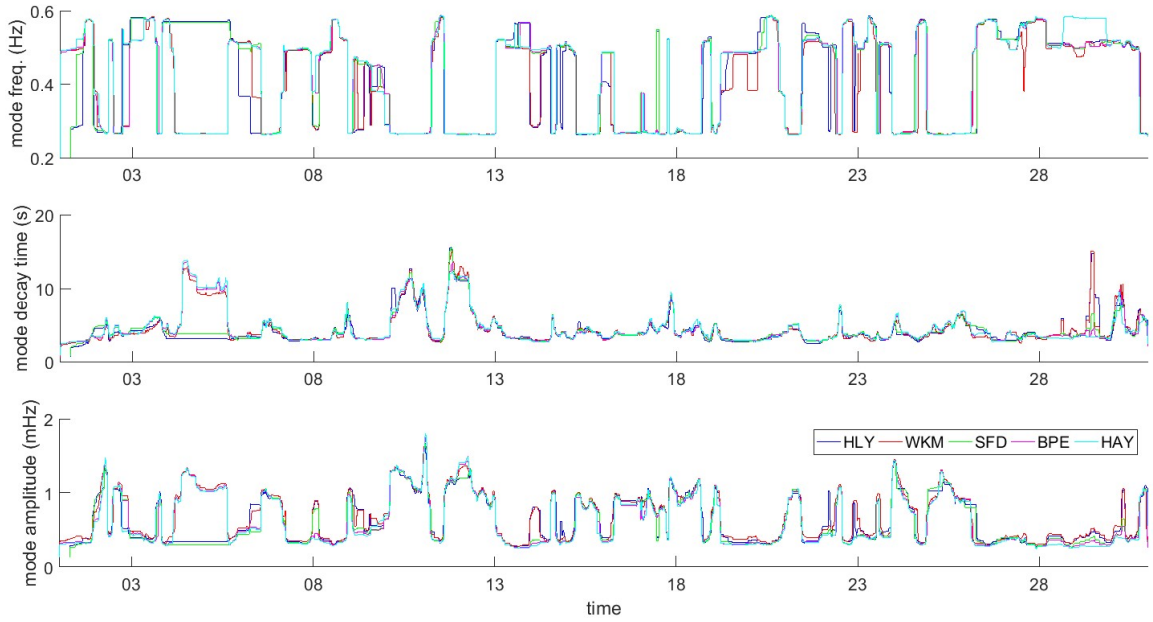


Figure 14: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

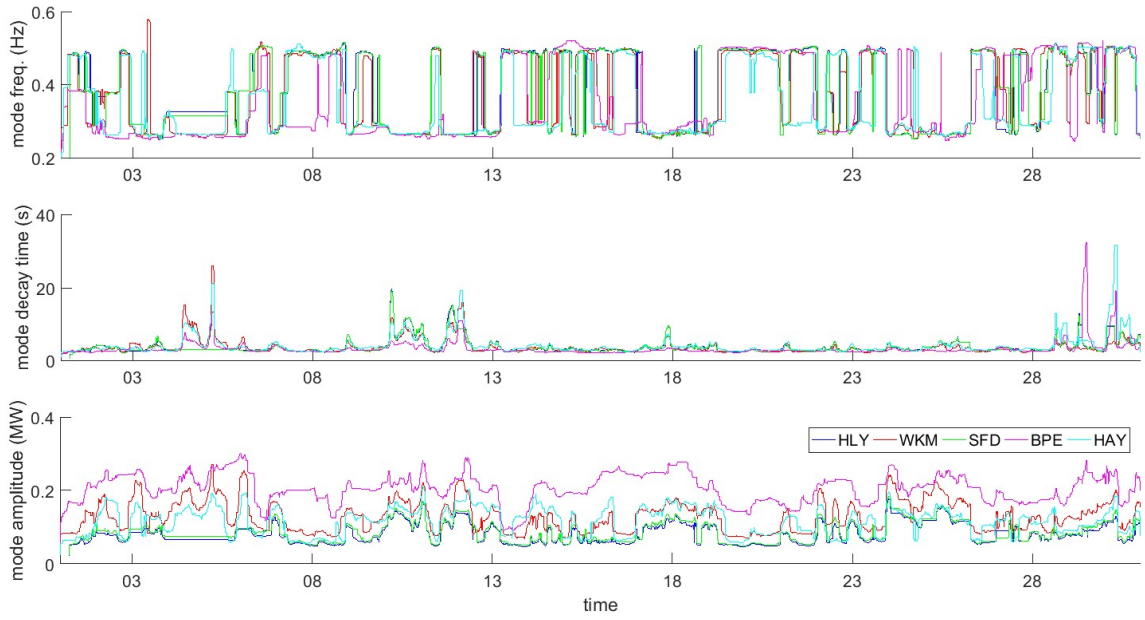


Figure 15: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data

Using PMU frequency

- 0.25 Hz mode, decay time around 5 seconds, increasing to 5-15 seconds at times throughout the month.
- 0.5 Hz-0.6 Hz, decay time around 5-15 seconds throughout the month.

Using active power:

- 0.25 Hz and 0.5 Hz modes at most sites.
- 0.25 Hz mode decay time between 5-25 seconds.
- 0.5 Hz mode decay around 5 seconds typically, but a period of much longer decay time at the end of the month as detailed in section 3.1.3 above.
- Maximum amplitude reported ~300kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

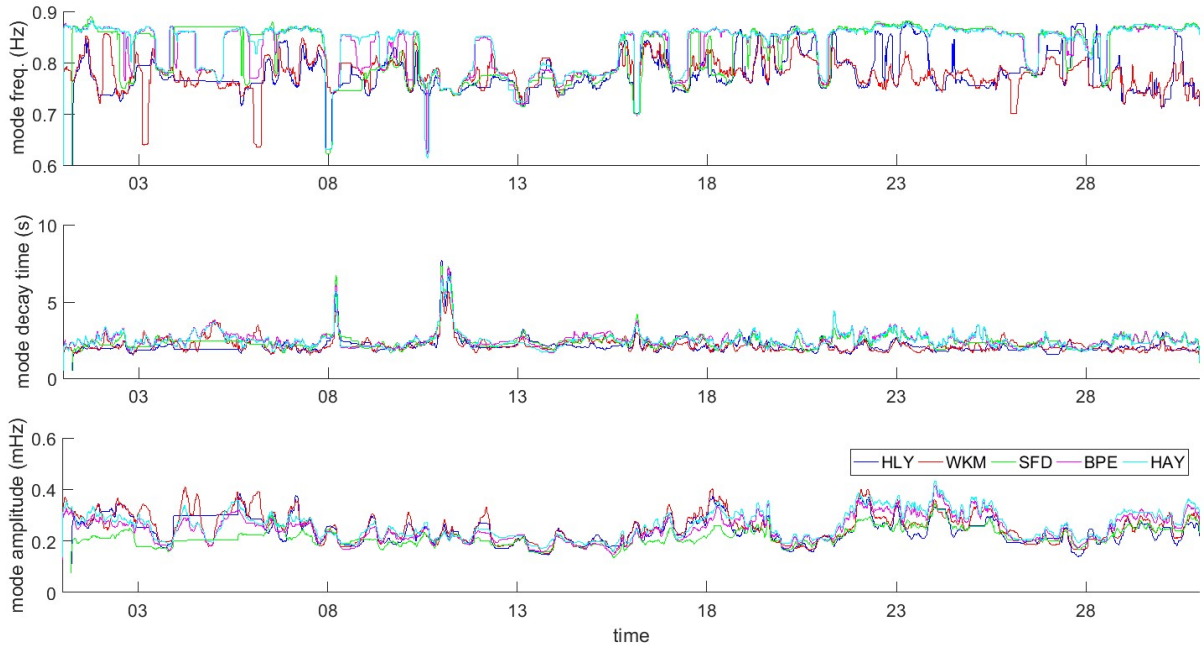


Figure 16: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

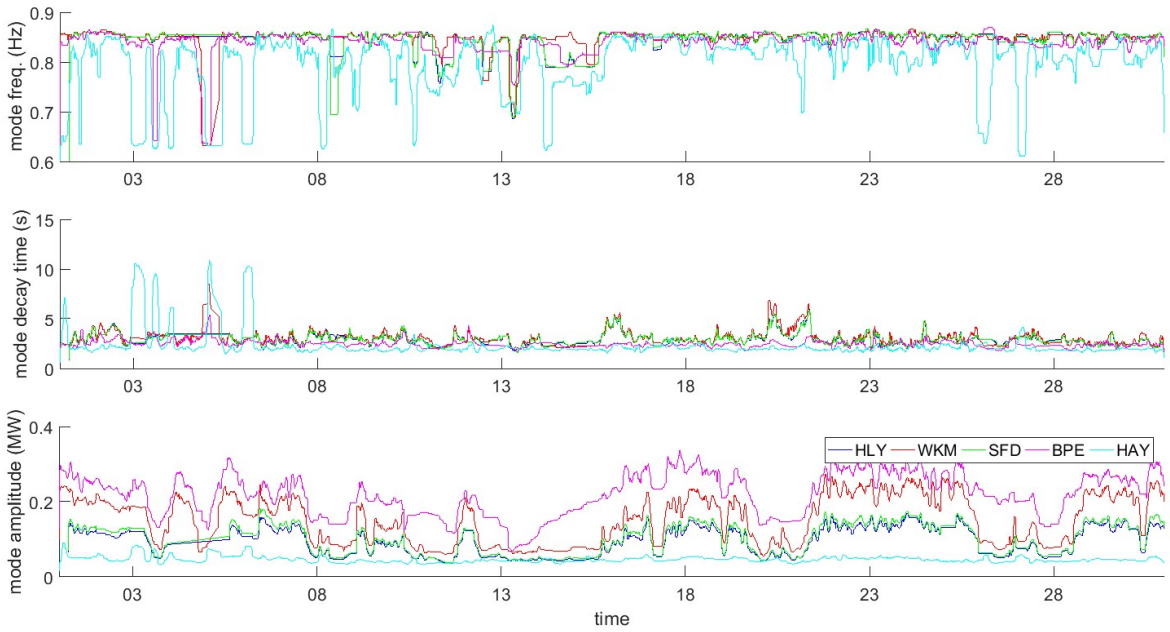


Figure 17: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Mode around 0.7 Hz – 0.9 Hz observed.
- Decay time typically less than 5 seconds at most sites occasionally peaking as high as 7 seconds.
- Maximum amplitude ~0.4 mHz.

Using active power

- Mode around 0.65 Hz reported at HAY at very low amplitude, generally the mode at 0.85 Hz observable.
- Decay time less than 5 seconds for the 0.85 Hz mode.
- Maximum amplitude at Bunnythorpe ~300 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

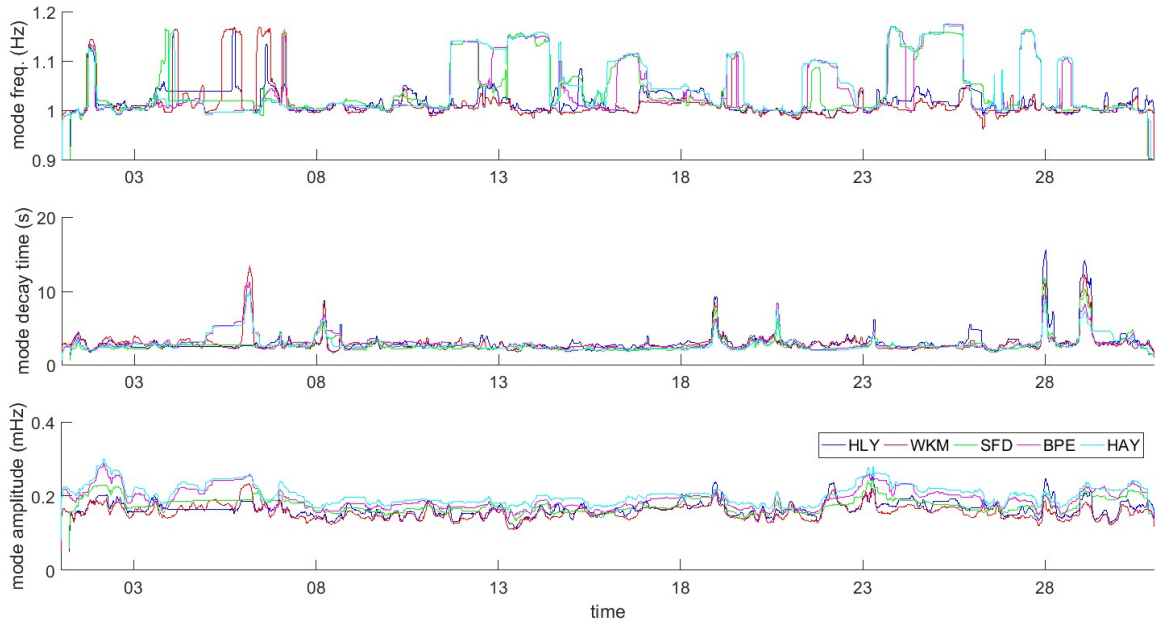


Figure 18: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

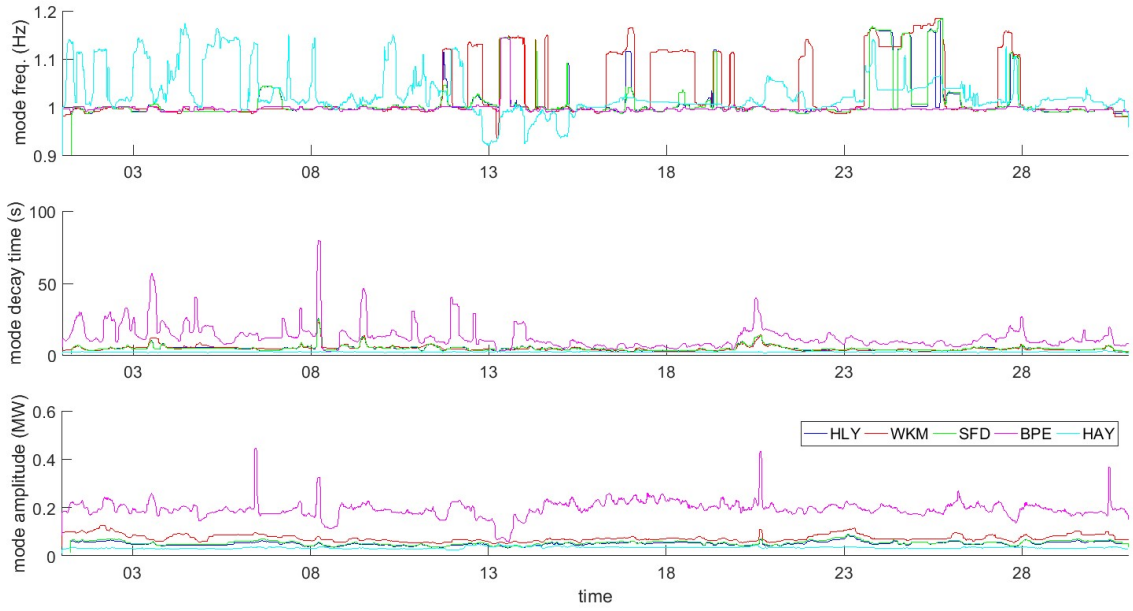


Figure 19: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at 1.00 Hz, ~1.1 Hz, and ~1.15 Hz.
- Mode 1 Hz peaks around 15 seconds observed at Huntly, but all low amplitude.
- Maximum amplitude ~0.3 mHz observed at Haywards and Bunnythorpe.

Using active power:

- Most modes are typically well damped, except for the 1 Hz mode observed at Bunnythorpe with a 75 second maximum decay time on the 8th. This mode has a relatively low amplitude with a maximum of ~0.4MW observed at Bunnythorpe.
- All other modes in this band have low oscillation amplitudes.

3.7 Mode band 5: [1.2 - 1.8 Hz]

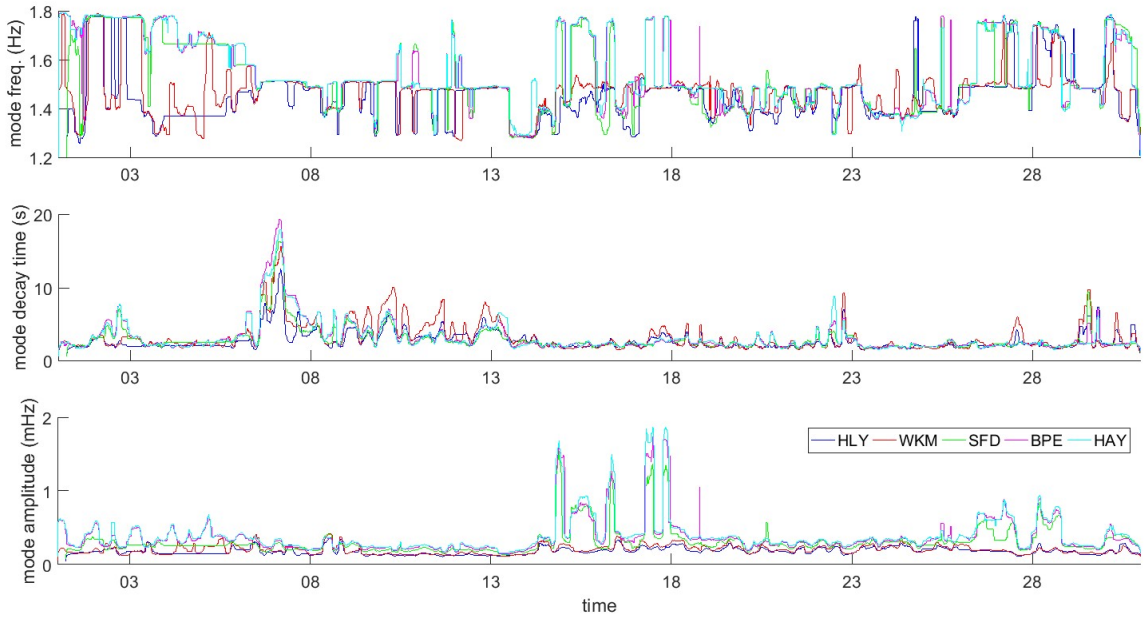


Figure 20: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

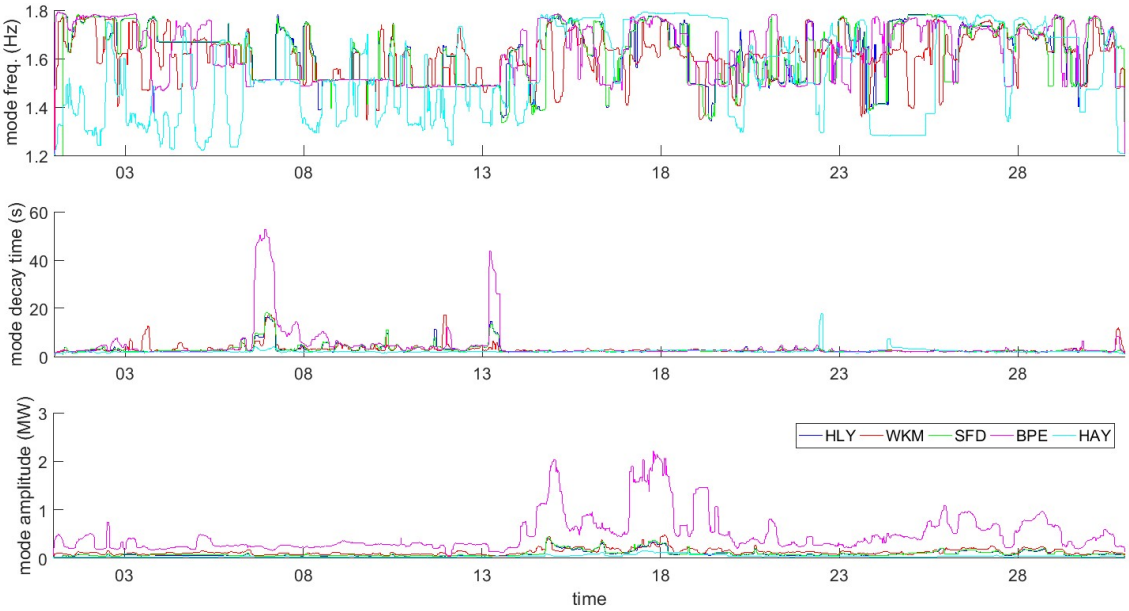


Figure 21: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

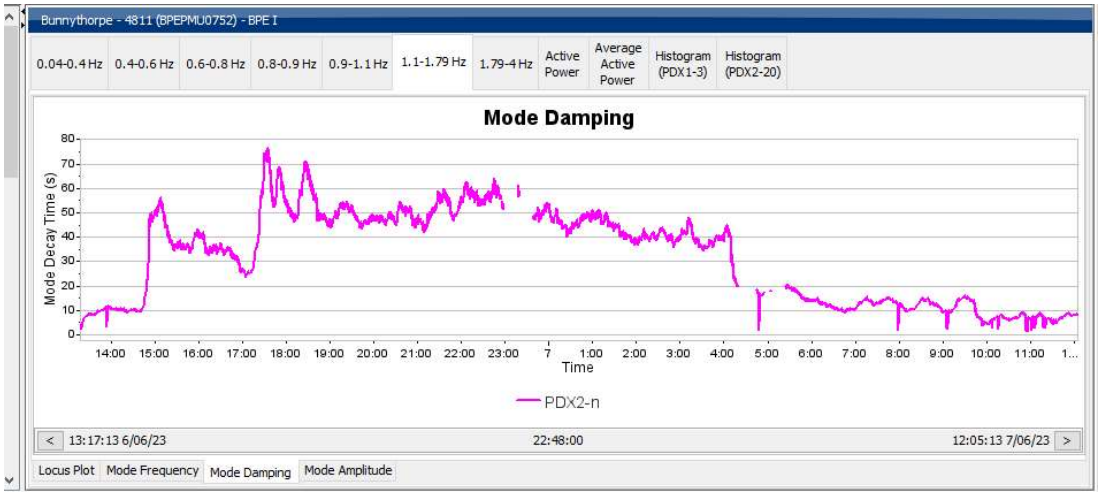
Using PMU frequency:

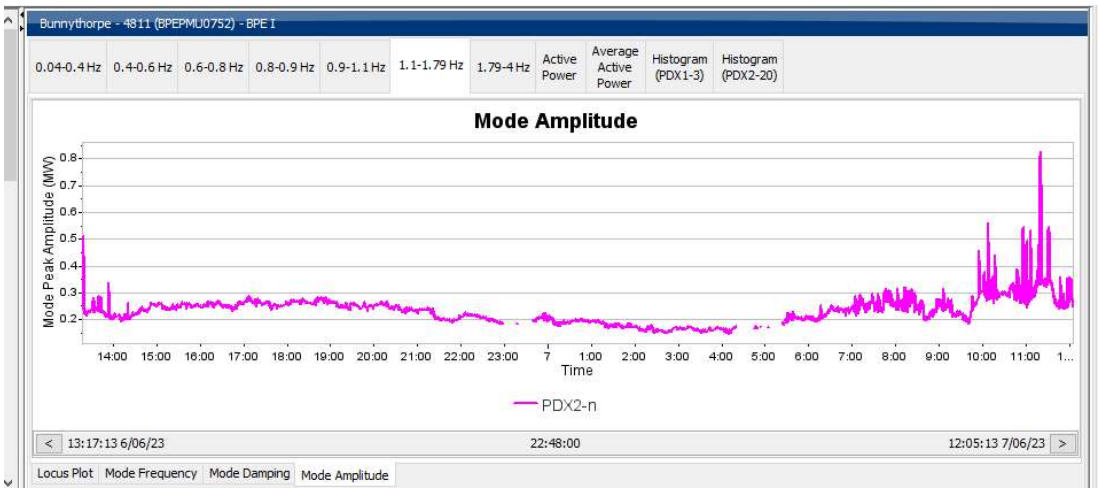
- Distinct modes around ~1.3 Hz, 1.5 Hz, and ~1.8 Hz.
- Maximum decay time ~20 seconds for the 1.5 Hz mode. Most of the month the decay time is less than 10 seconds for all modes.
- Maximum amplitude ~2 mHz observed at Bunnythorpe for ~1.8 Hz. Most mode amplitudes were observed to be less than 0.5 mHz throughout the month.

Using active power:

- Most modes appear to be relatively well damped except mode 1.5 Hz where the peak decay time observed was ~50 seconds at Bunnythorpe at certain periods. This was low amplitude and there was considerable involvement of local mode 1.0 Hz oscillation resulting in the low damping assessments.
- Maximum amplitude ~2MW observed for 1.8 Hz at Bunnythorpe around the 17th June, but well damped.

One example of the low amplitude, low damping of 1.5 Hz was reported overnight on the 6th/7th June





3.8 Mode band 6: [1.8 – 2.4 Hz]

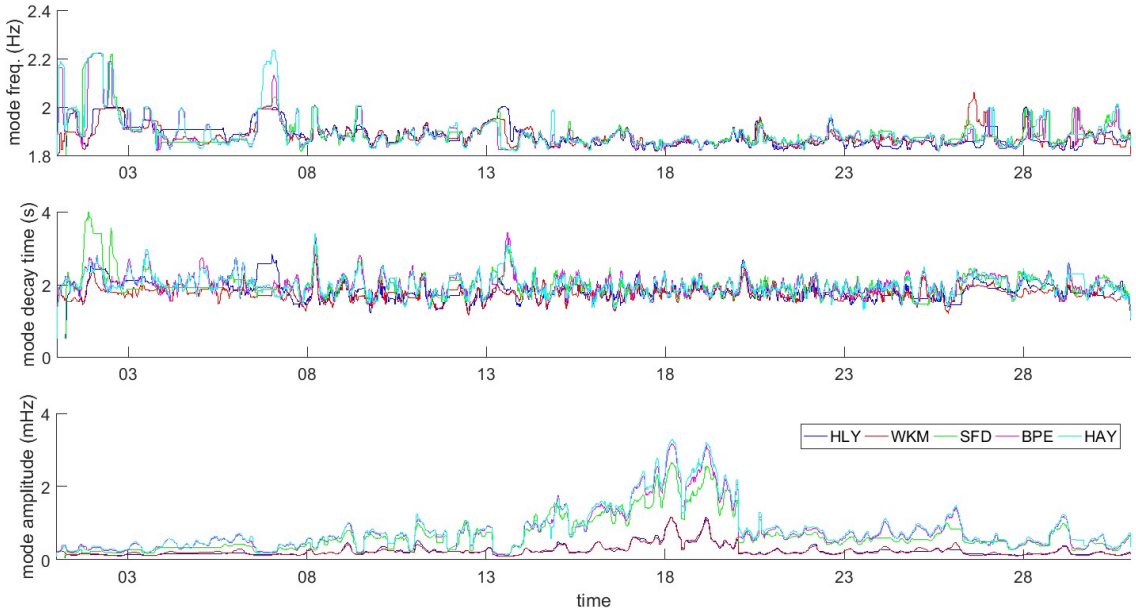


Figure 22: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

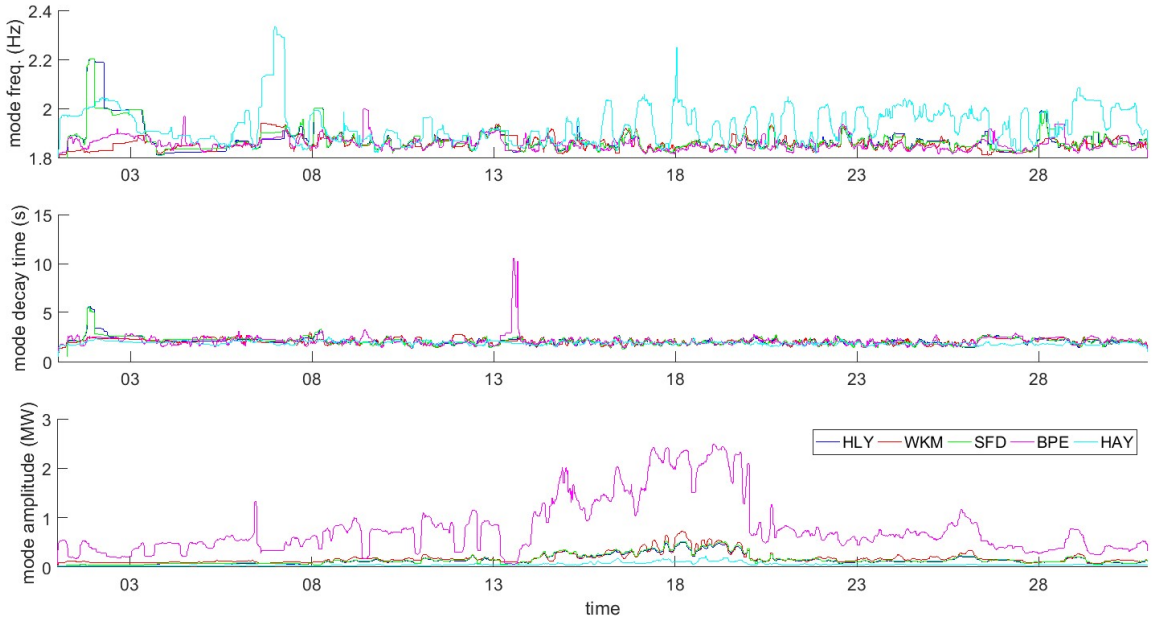


Figure 23: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes at ~1.9 Hz, 2 Hz and 2.2 Hz observed.
- All modes in this band are relatively well-damped.
- Maximum amplitude ~3mHz for the 1.9 Hz mode.

Using active power:

- All modes in this band are well-damped.
- Maximum oscillation amplitude for this mode band ~2.5 MW particularly visible at Bunnythorpe around the middle of the month.

3.9 Mode band 7: [2.4 – 4 Hz]

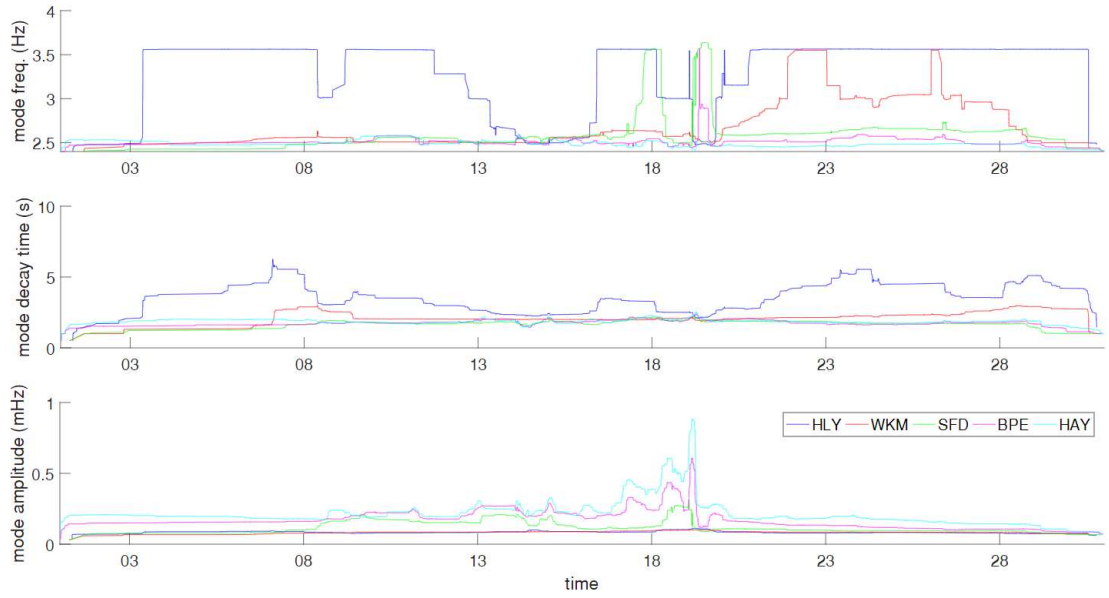


Figure 24: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

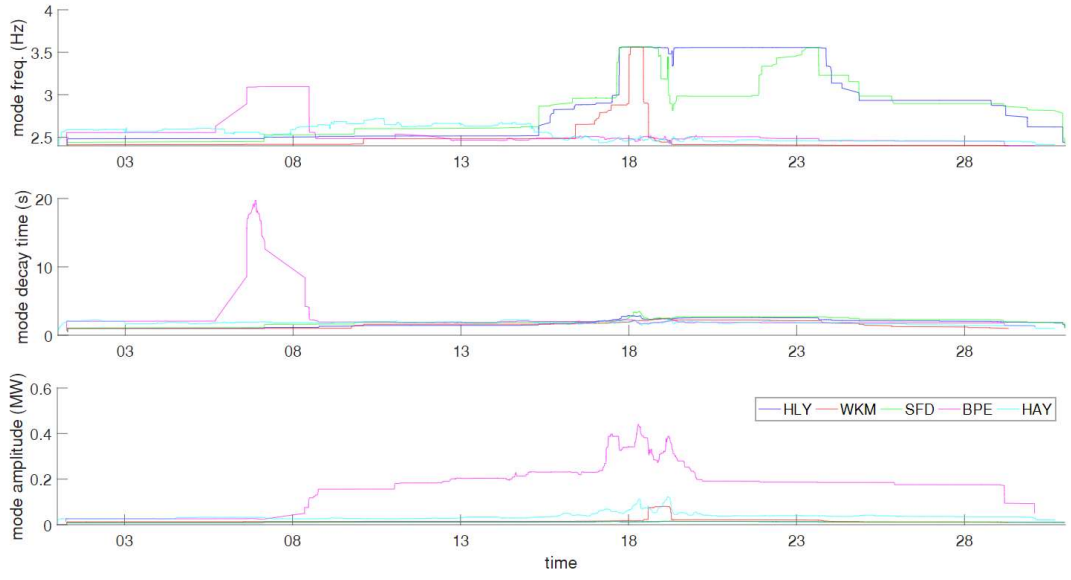


Figure 25: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Modes observed at 2.4-2.5 Hz at most sites and 3.5 Hz at Huntly.
- All modes in this band are low amplitude and well-damped in the frequency data.

Using active power:

- Mode reported at ~3.1 Hz at Bunnythorpe. This mode has the maximum decay time at 20 seconds, but it is very low amplitude.
- All other modes in this band are well-damped.

