

DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – APRIL 2023

Transpower New Zealand Limited

April 2023

Keeping the energy flowing



TRANSPOWER



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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 April 2023. This monthly report presents these findings for April 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 April 2023
0.04 Hz	Most-f All-p	Governor modes	Well-damped No significant change over the month
0.25 Hz	All-f Most-p	Likely control modes, and non-electromechanical	Decay time up to 40s Relatively high number of occurrences
0.5 – 0.6 Hz	All-f	Possibly interarea modes	Decay time up to 20s Low amplitude
0.9-1 Hz	Most-f Most-p	Inter-area and Inter-station modes	Decay time up to 65s at BPE Relatively low amplitude
1.7-1.9 Hz	All-f All-p	Inter-station and Local modes	Most sites well damped Periods of relatively high amplitude High number of occurrences
2.4 - 2.5 Hz	BPE-f/p HAY-f/p WKM-f/p	Not yet identified	High decay time up to 55 seconds Low amplitude Low number of occurrences

3.5 Hz	HLV-f	Not yet identified	Low number of occurrences Well damped
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The Wairakei PMU was disconnected from the start of 2023 through to 5th October.

3 Detailed plots for April 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

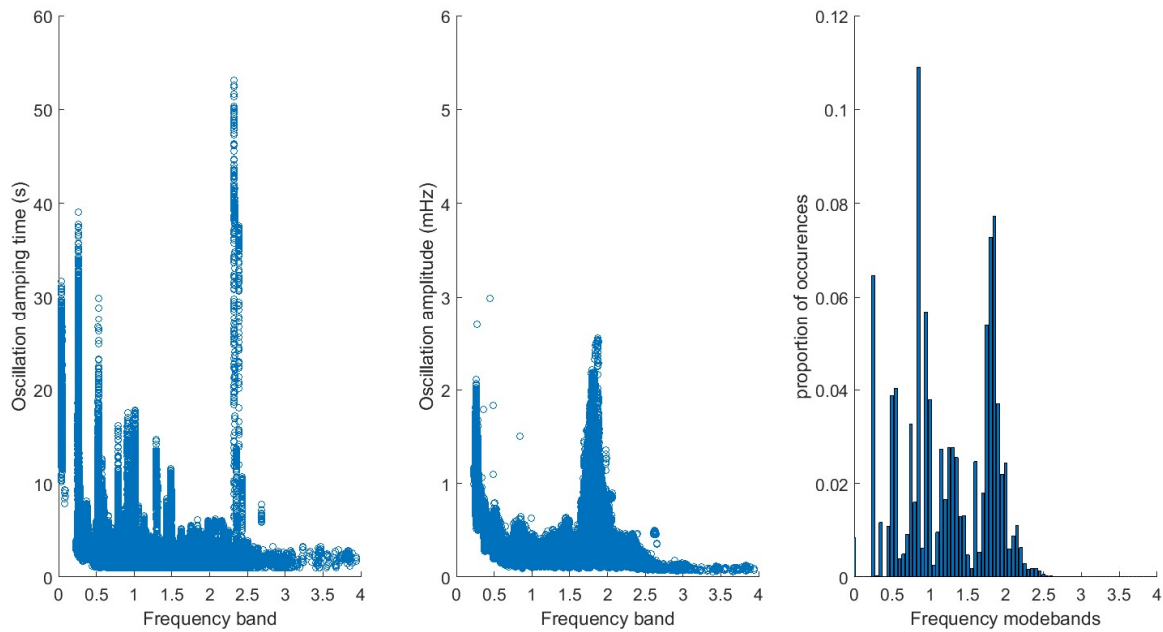


Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

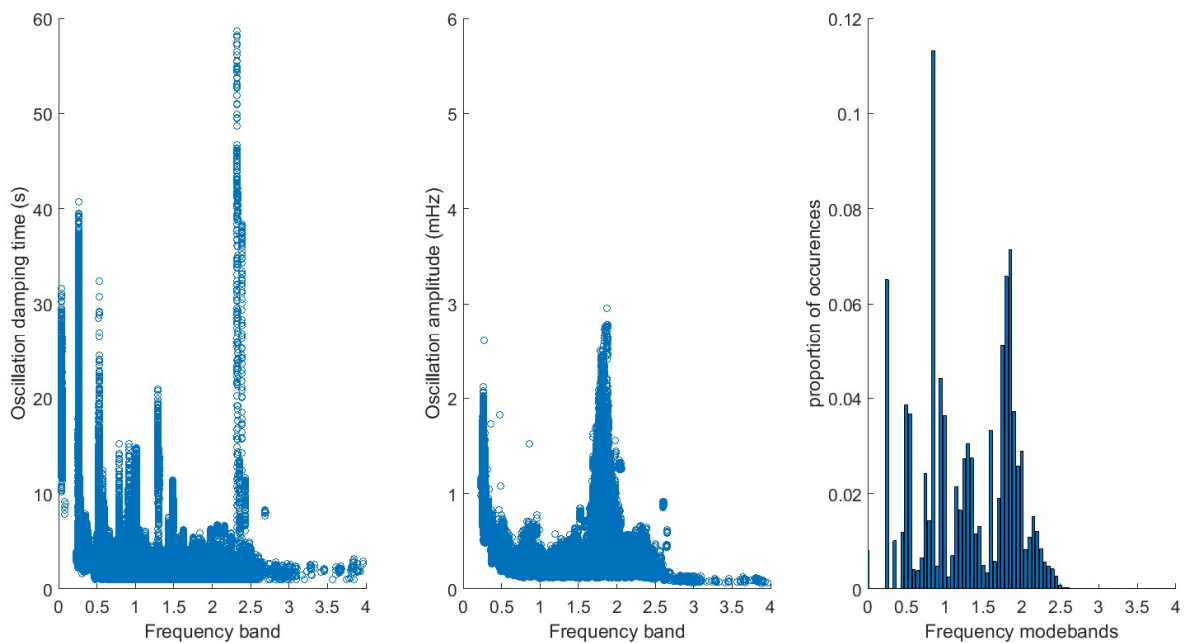


Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

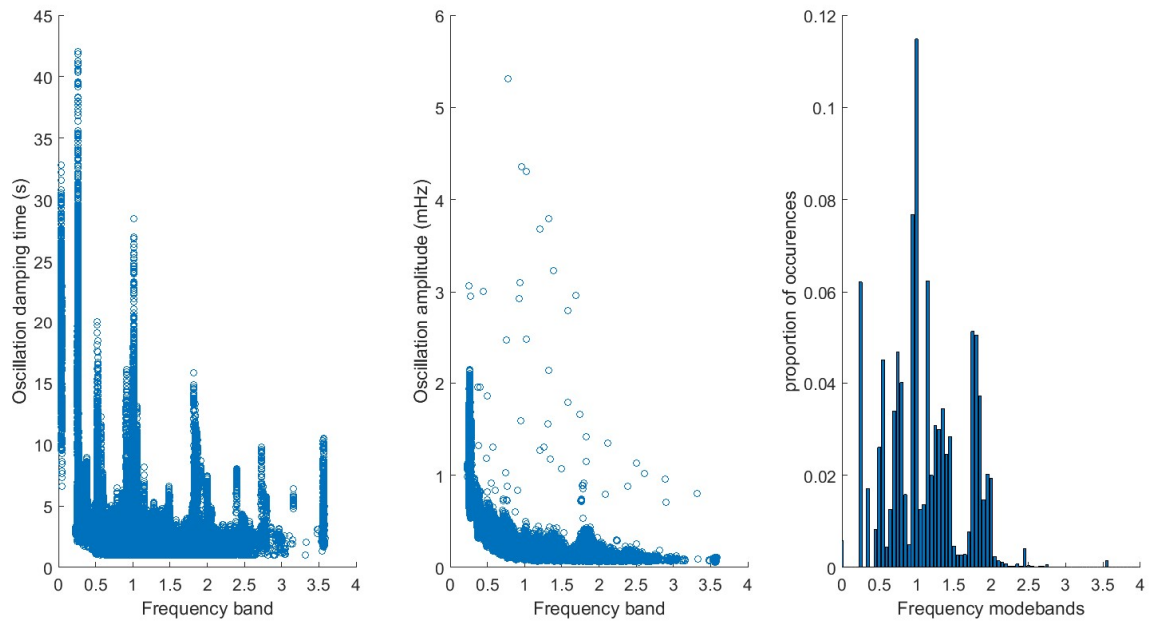


Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

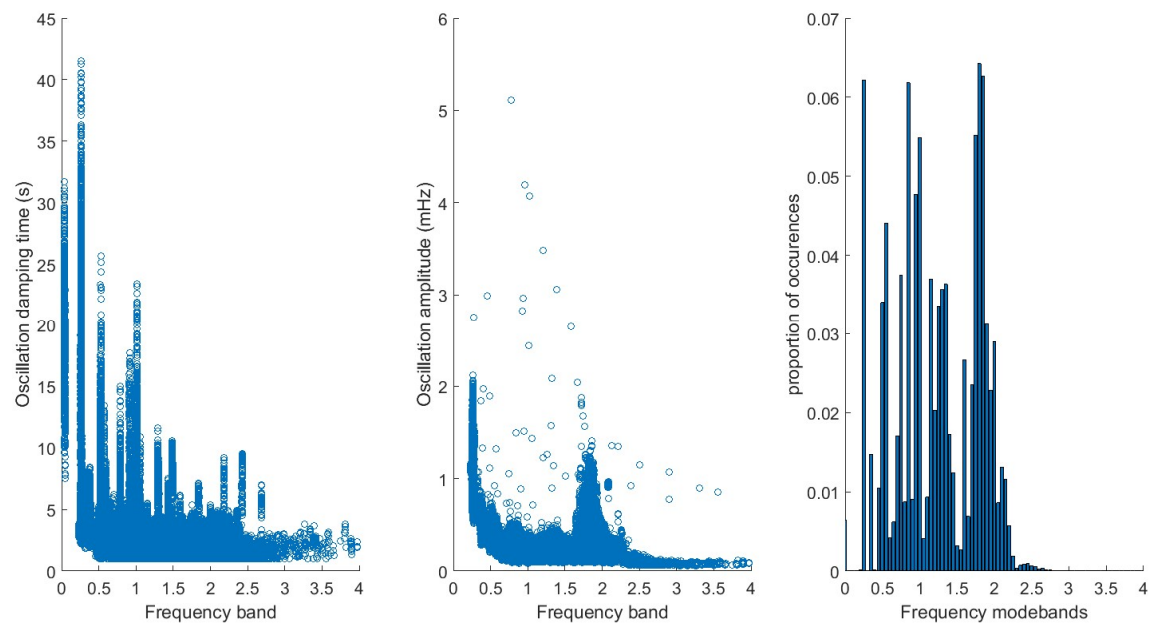


Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

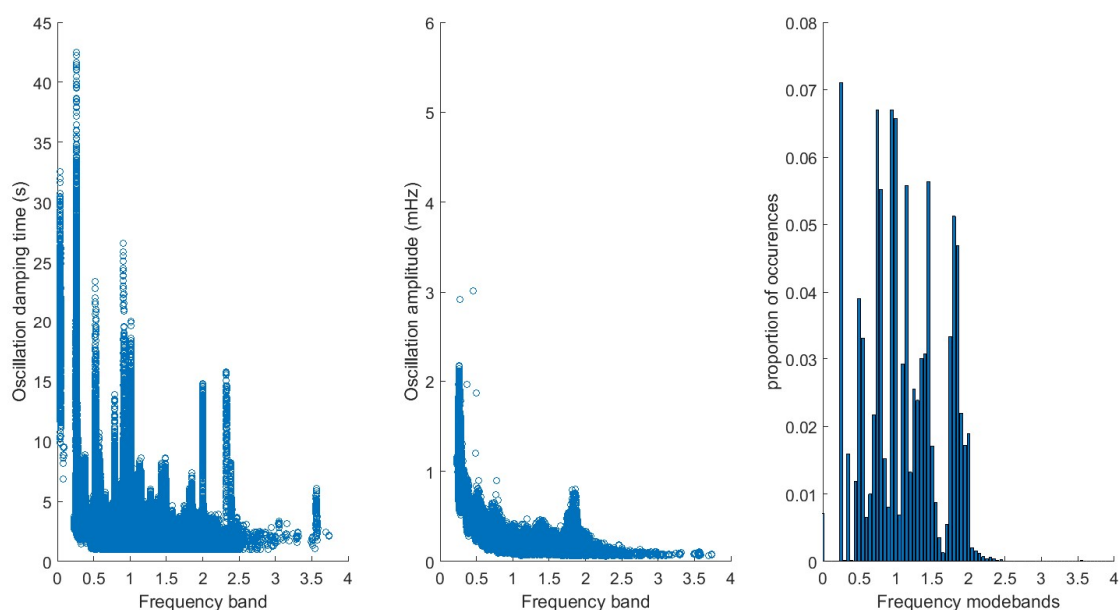


Figure 5: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

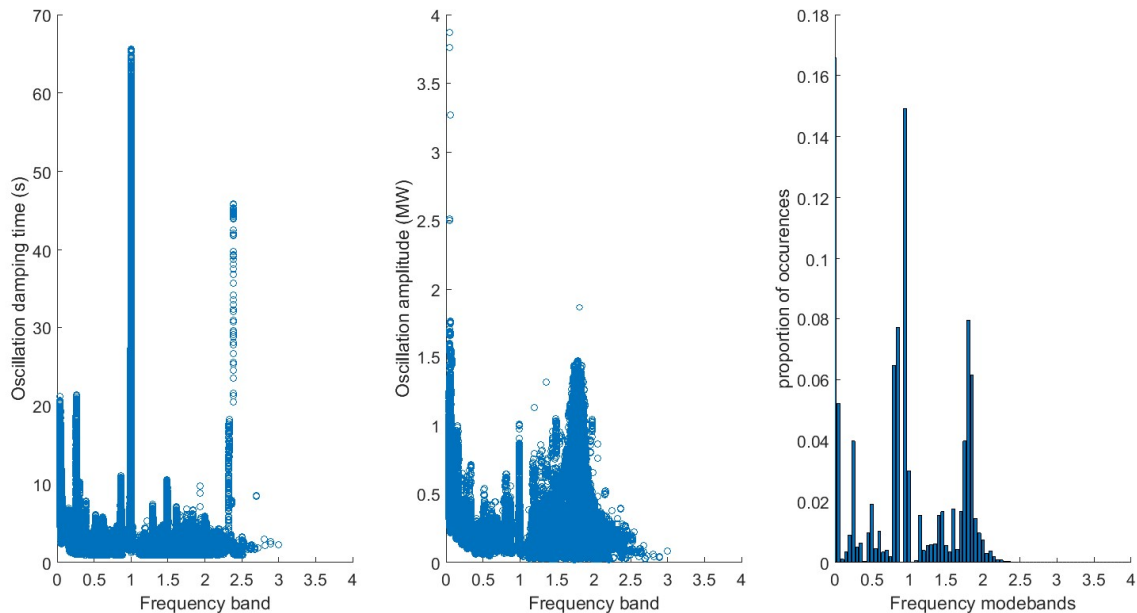


Figure 6: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

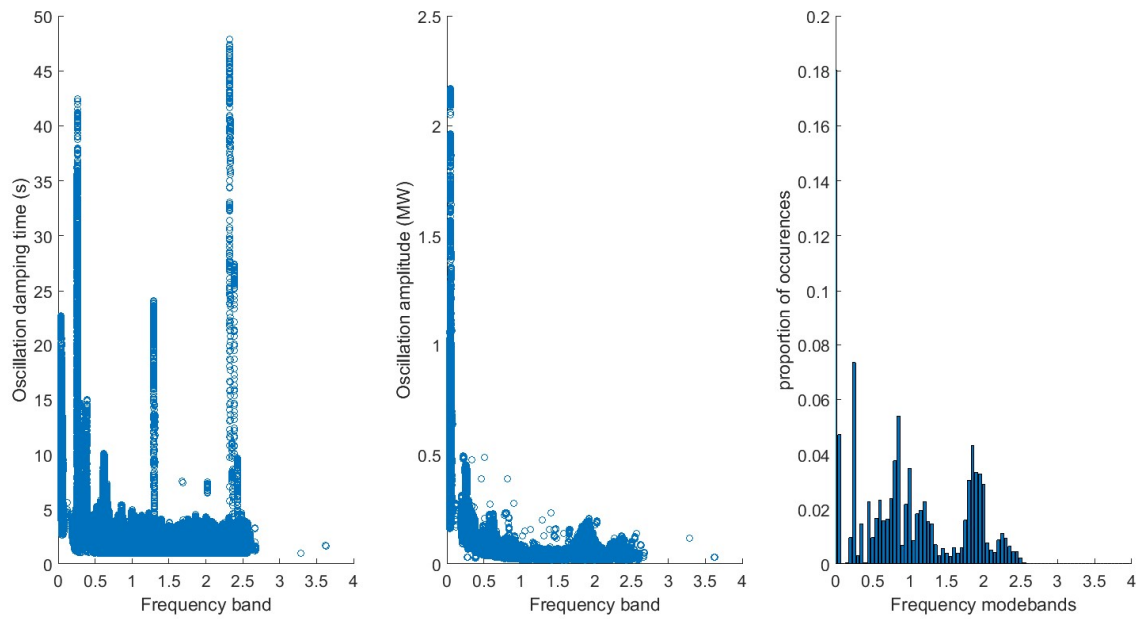


Figure 7: Haywards mode damping, mode amplitude, and frequency histogram using active power data

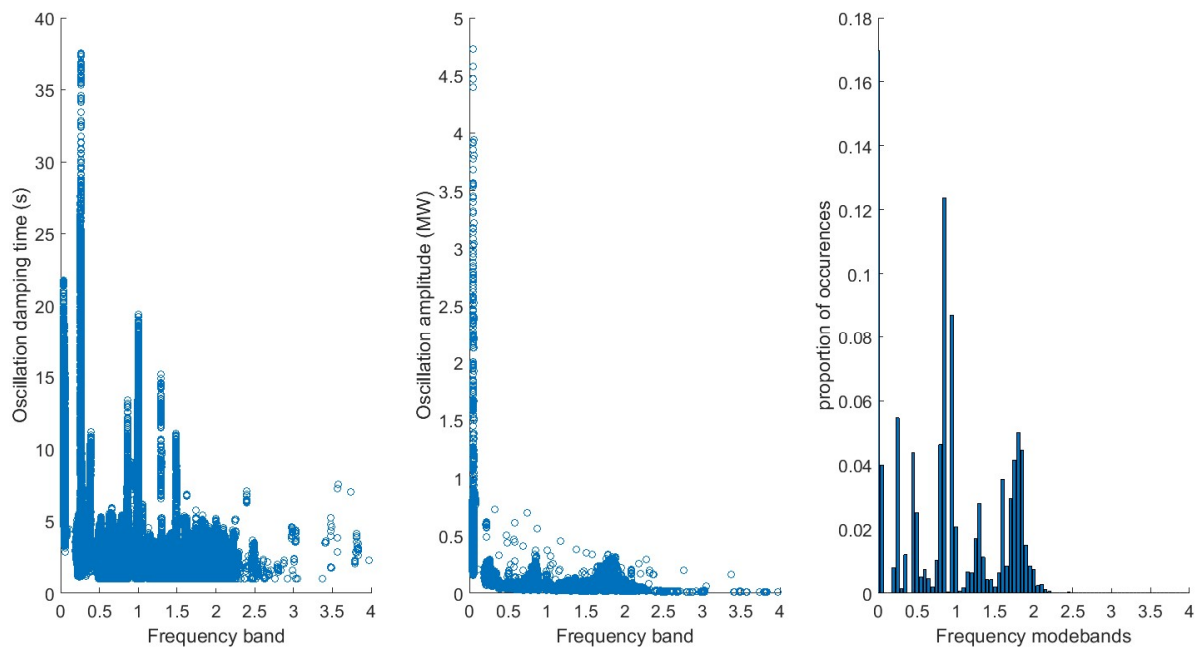


Figure 8: Huntly mode damping, mode amplitude, and frequency histogram using active power data

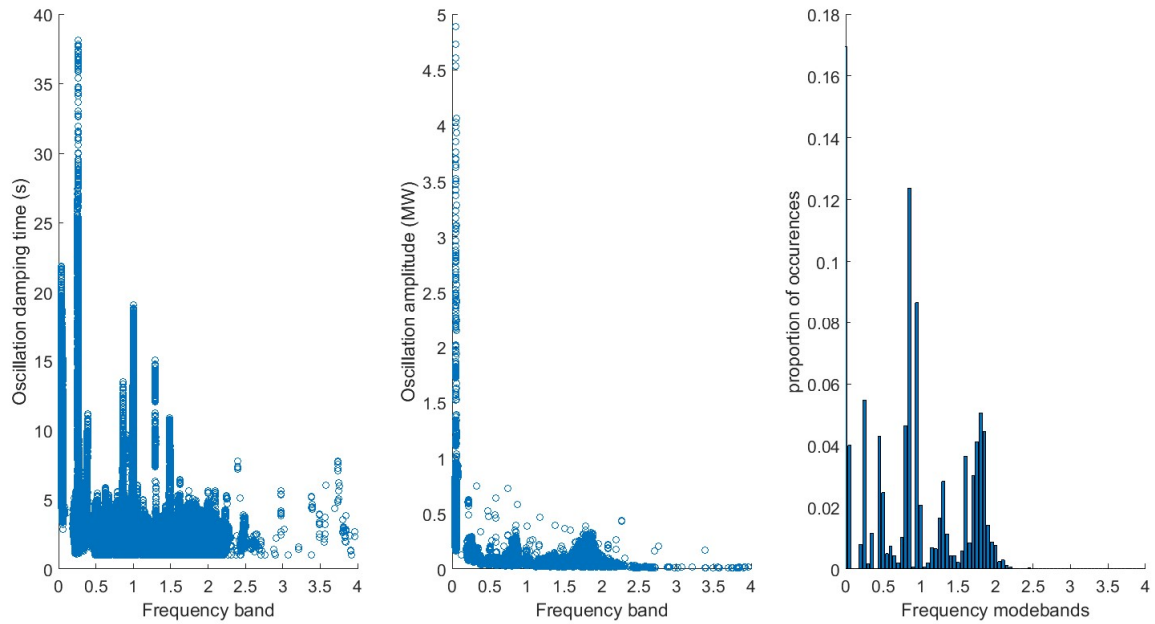


Figure 9: Stratford mode damping, mode amplitude, and frequency histogram using active power data

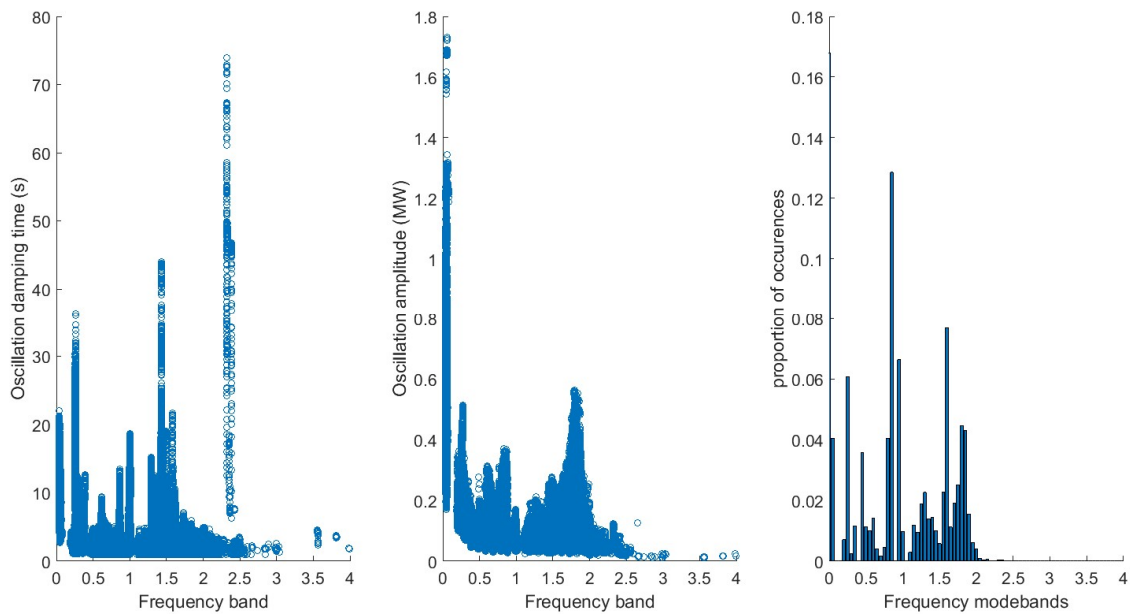


Figure 50: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

3.1.3 Observations using the frequency histograms

From the histograms, it can be observed that some modes have a large percentage of occurrences. Distinct modes at approximately 0.25 Hz, 1 Hz and 1.8 Hz can be observed in the April data.

The lower NI sites also report poor damping at around 2.5 Hz but at low amplitudes.

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
- 0.9-1 Hz
- 1.5-1.6 Hz
- 1.8 Hz
- 2.4- 2.5 Hz
- 3.5 Hz

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
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3.3 Mode band 1: [0.0 – 0.2 Hz]

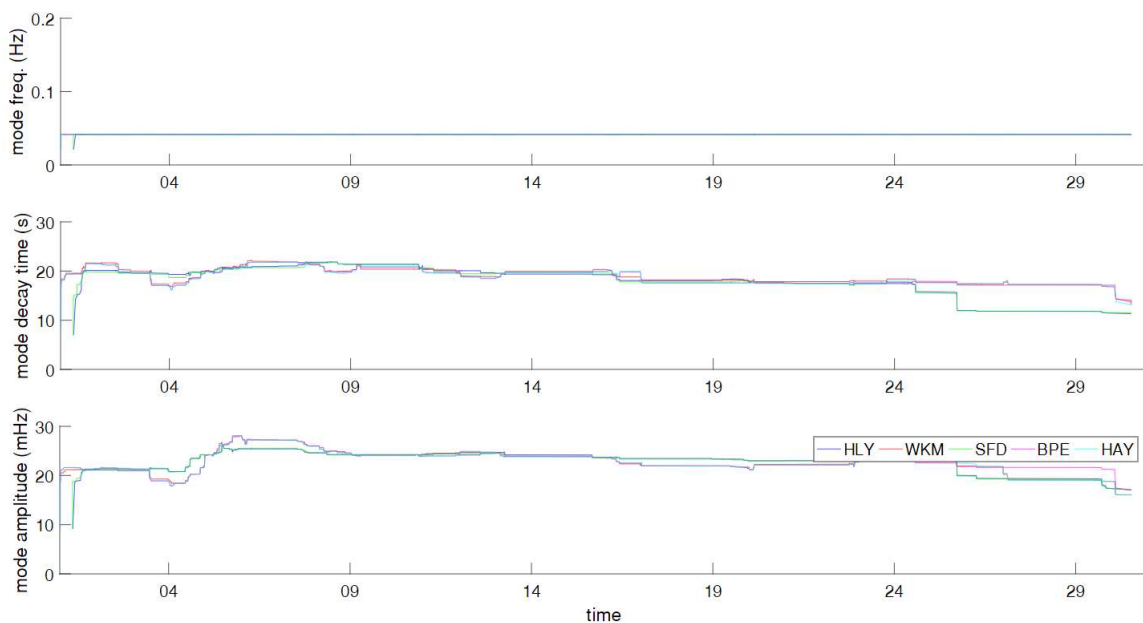


Figure 6: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

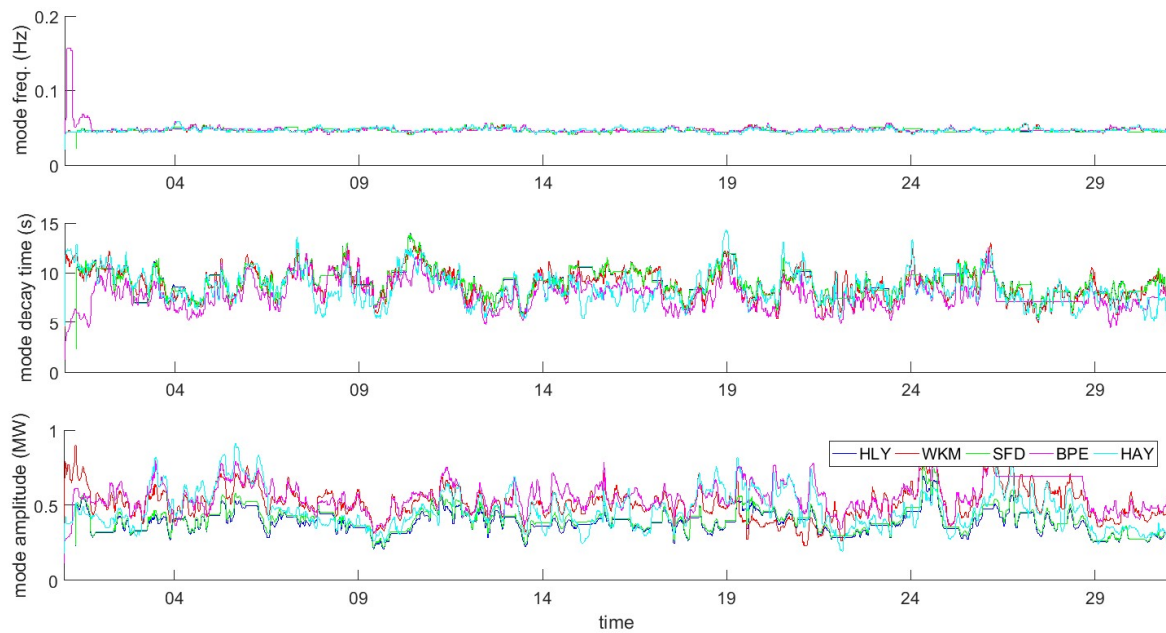


Figure 72: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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 throughout the month. 0.15 Hz mode observed at the start of the month at Bunnythorpe.
- All modes are well damped.

3.4 Mode band 2: [0.2 – 0.6 Hz]

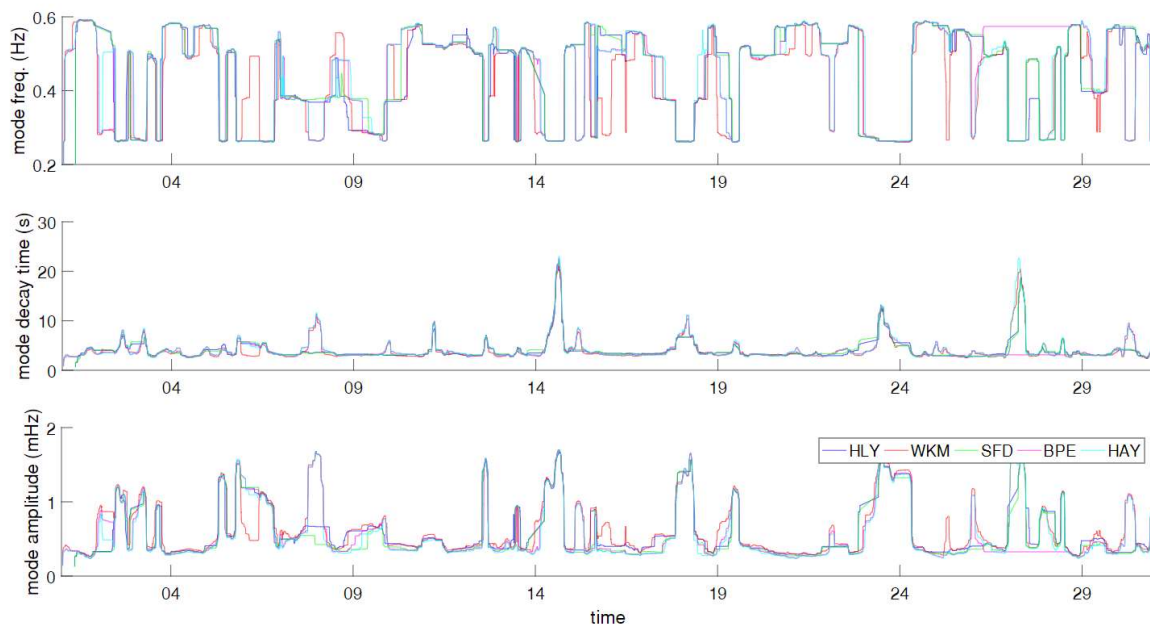


Figure 13: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

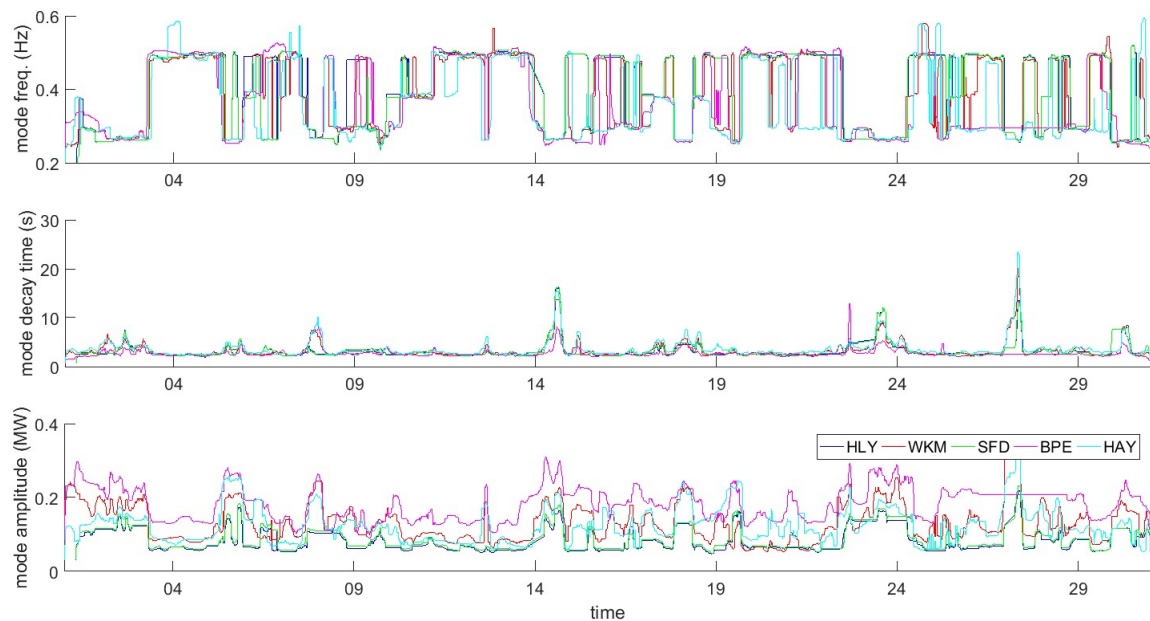


Figure 14: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency:

- 0.25 Hz mode, decay time increasing to 10-20 seconds at times throughout the month.
- 0.4 Hz-0.6 Hz, decay time around 5-10 seconds throughout the month.

Using active power:

- 0.25 Hz and ~0.4-0.6 Hz mode at most sites.
- 0.25 Hz mode decay time usually around 5 seconds with occasional peaks of up to 20 seconds.
- ~0.4-0.6 Hz mode decay around 5 seconds when dominant.

3.5 Mode band 3: [0.6 – 0.9 Hz]

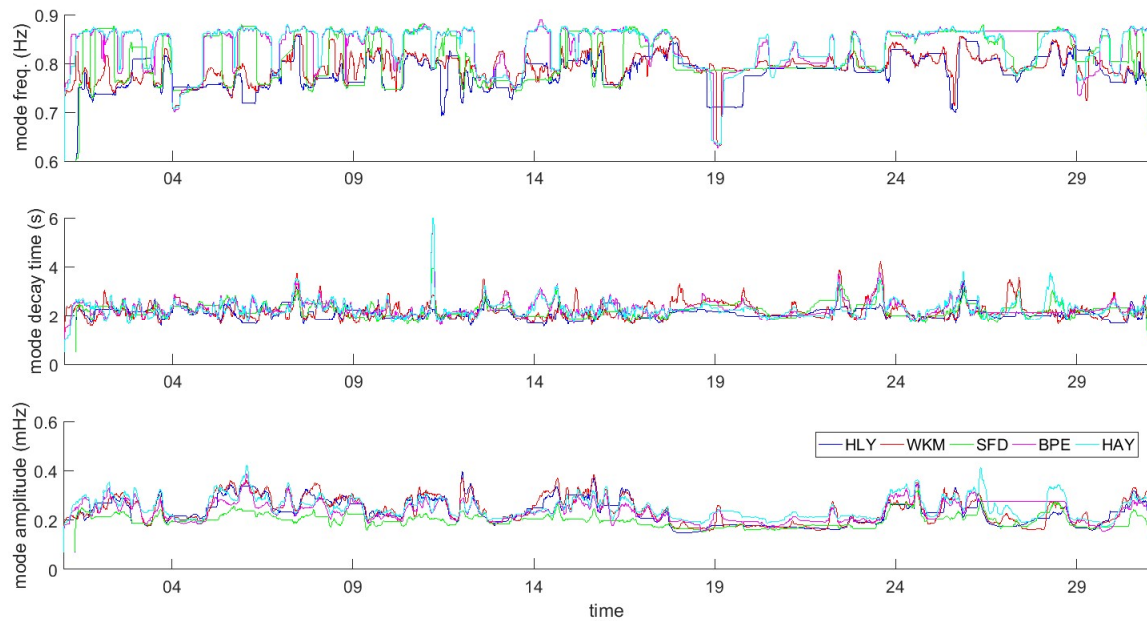


Figure 15: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

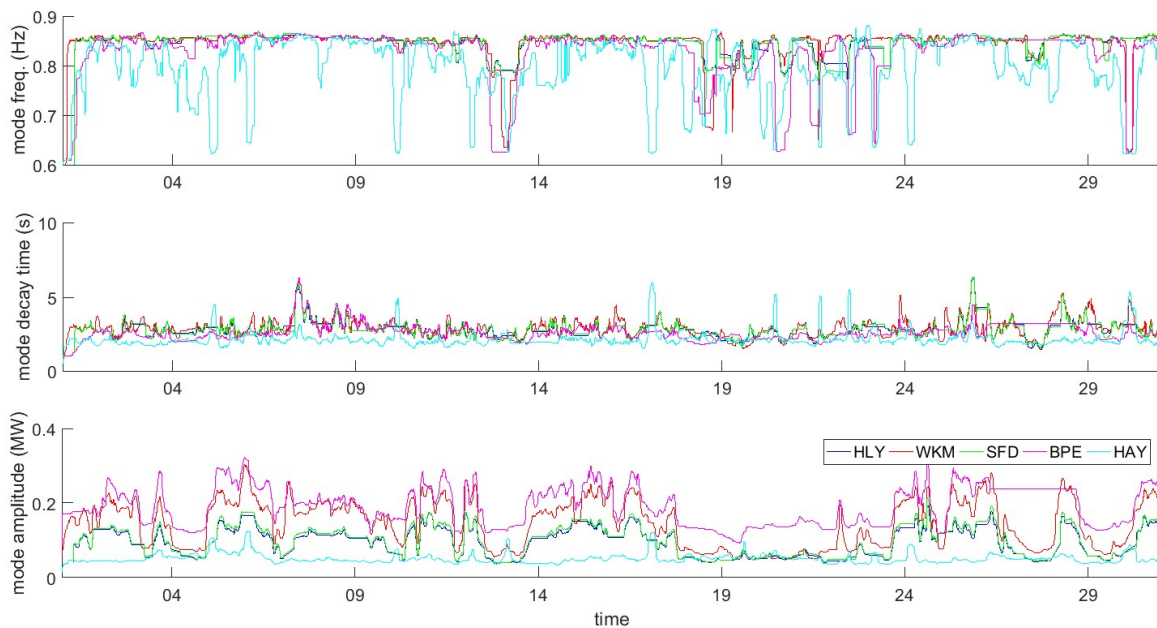


Figure 86: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Mode around 0.6 Hz – 0.85 Hz mode observed.
- Decay time typically less than 5 seconds at most sites, always well damped.
- Maximum amplitude ~0.4 mHz.

Using active power:

- Modes around 0.6 Hz and 0.75 Hz – 0.85 Hz observable.
- Decay time less than 7 seconds at most sites.
- Maximum amplitude at Bunnythorpe ~300 mW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

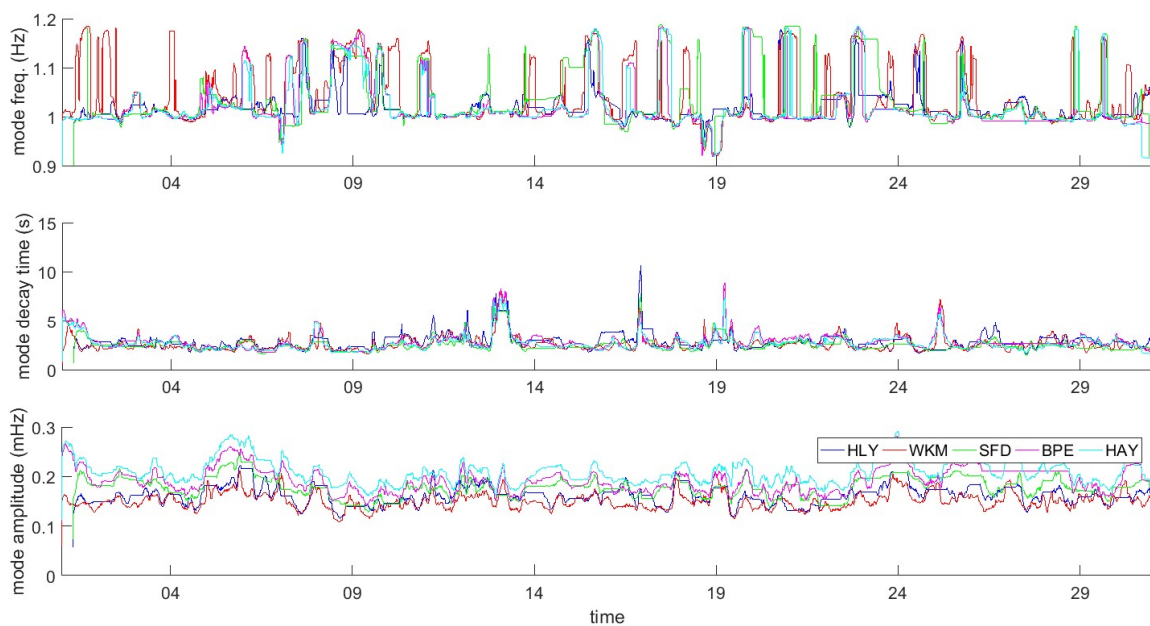


Figure 97: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

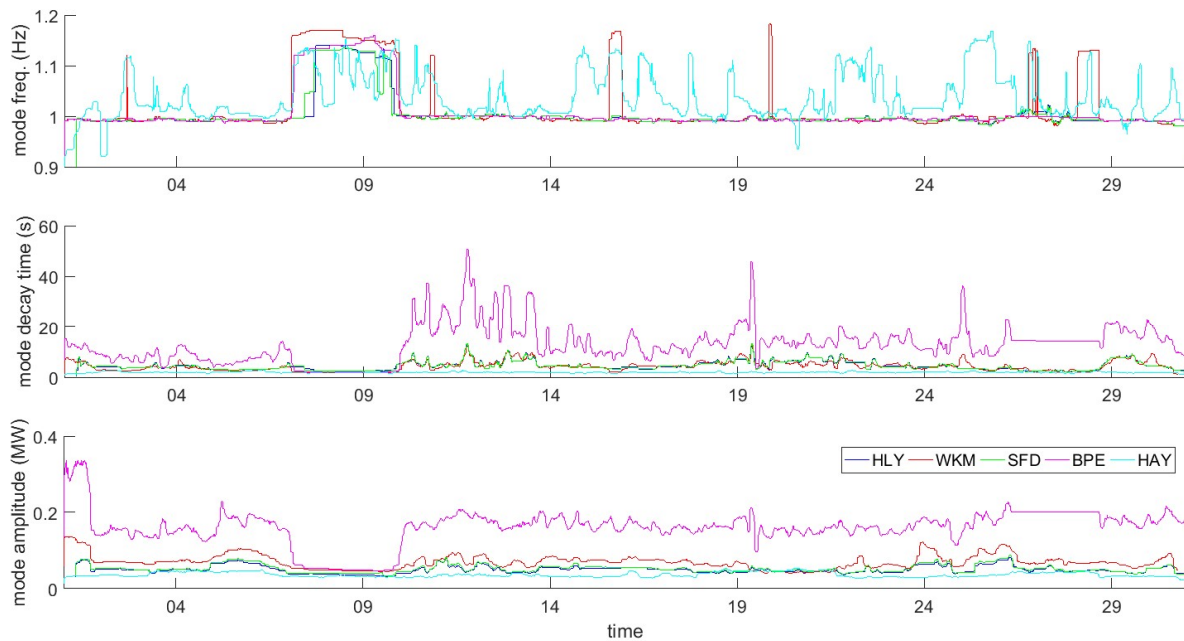


Figure 18: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at ~0.93 Hz, 1.00 Hz, 1.05 Hz, and 1.18 Hz.
- All decay times are under 10 seconds.

Using active power:

- Most modes are typically well damped. However, the 1 Hz mode at Bunnythorpe has occasional decay time peaks of up to 50 seconds during the month.
- Most modes in this band have low oscillation amplitudes. The maximum magnitude observed was 300 KW at Bunnythorpe, which is still relatively low.

3.7 Mode band 5: [1.2 - 1.8 Hz]

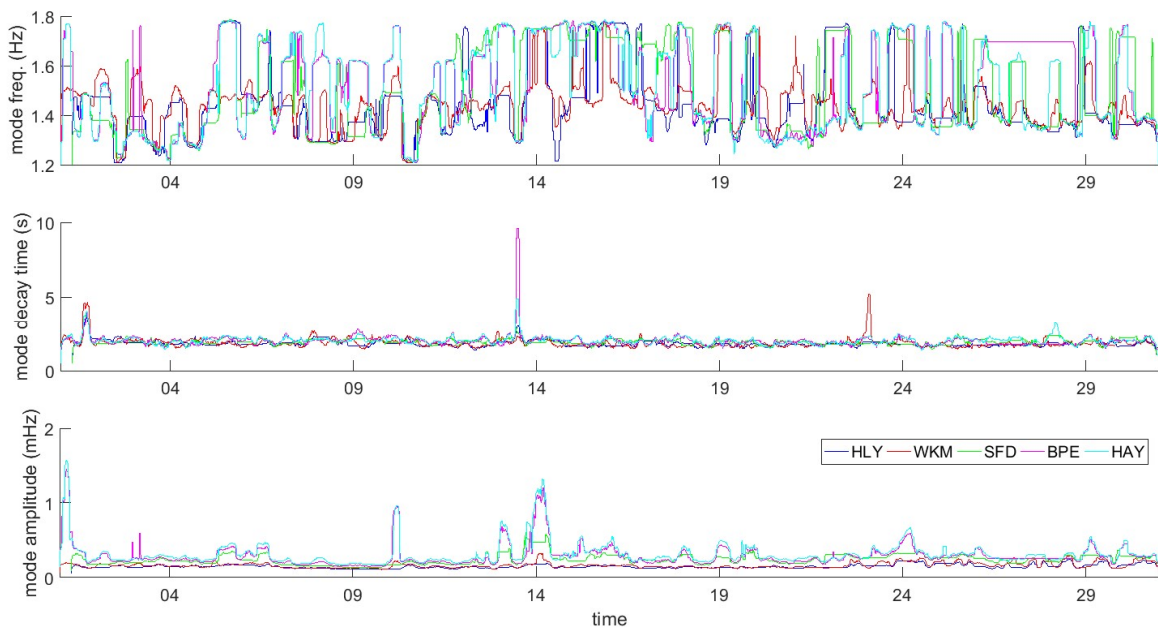


Figure 19: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

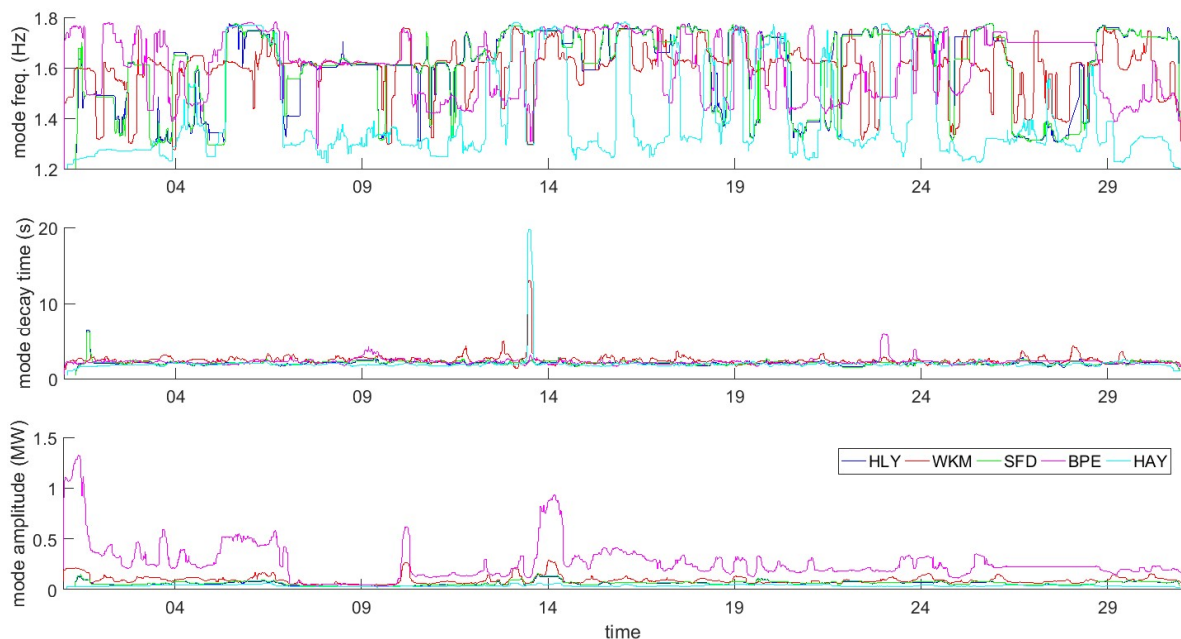


Figure 20: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes around 1.2 Hz, 1.3-1.5 Hz, 1.6, and ~1.8 Hz.
- Maximum decay time 15 seconds, observed at Haywards and Bunnythorpe on April 13th. This was at 1.3 Hz and low magnitude. Most of the month the decay time is less than 5 seconds for all modes.

- Maximum amplitude ~1.5 mHz observed at Bunnythorpe and Haywards for ~1.8 Hz. Most mode amplitudes observed to be less than 1 mHz throughout the month.

Using active power:

- Maximum decay time 20 seconds, observed at Haywards on April 13th at 1.3 Hz. All modes are well damped for the rest of the month.
- Maximum amplitude ~1 MW observed for 1.8 Hz at Bunnythorpe

3.8 Mode band 6: [1.8 – 2.4 Hz]

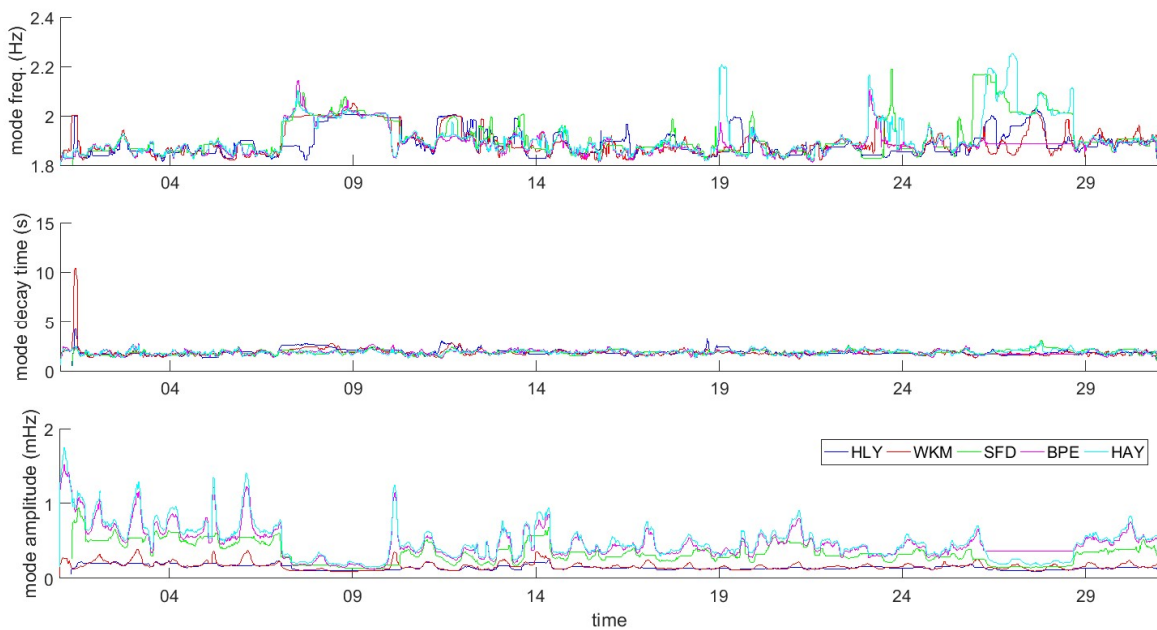


Figure 101: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

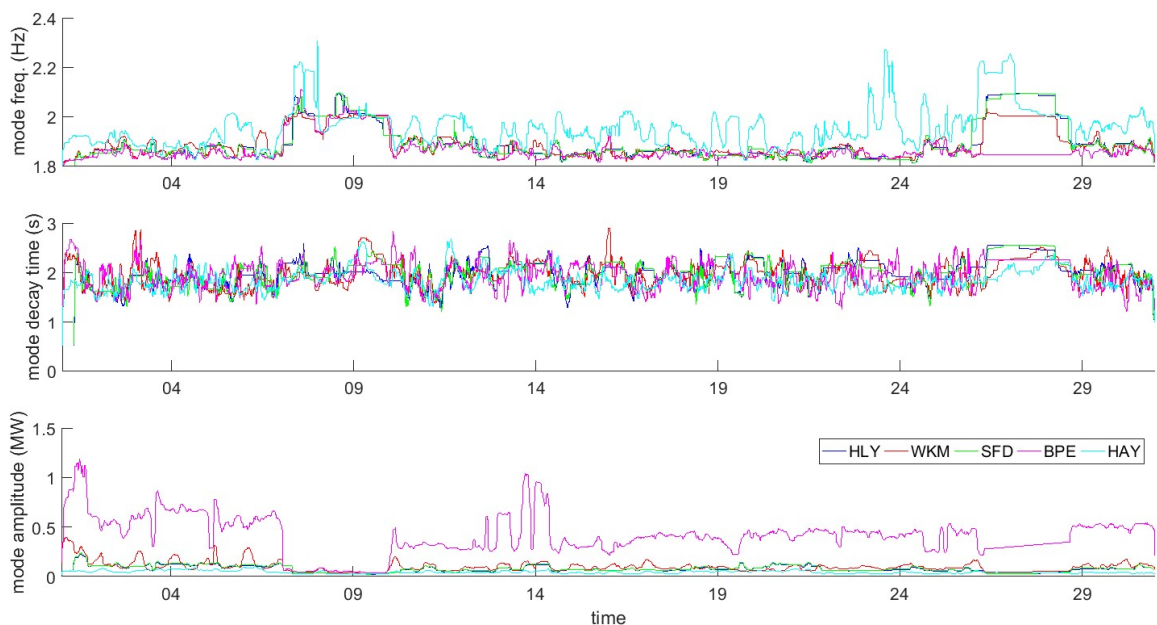


Figure 22: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes at 1.8 Hz, 2 Hz, and 2.2 Hz observed.
- All modes in this band are relatively well-damped.
- Mode 2 Hz decay time peaked at around 10 seconds earlier in the month.

Using active power:

- All modes in this band are relatively well-damped.
- Maximum oscillation amplitude for this mode band ~1 MW particularly visible at Bunnythorpe around the start and the middle of the month.

3.9 Mode band 7: [2.4 – 4 Hz]

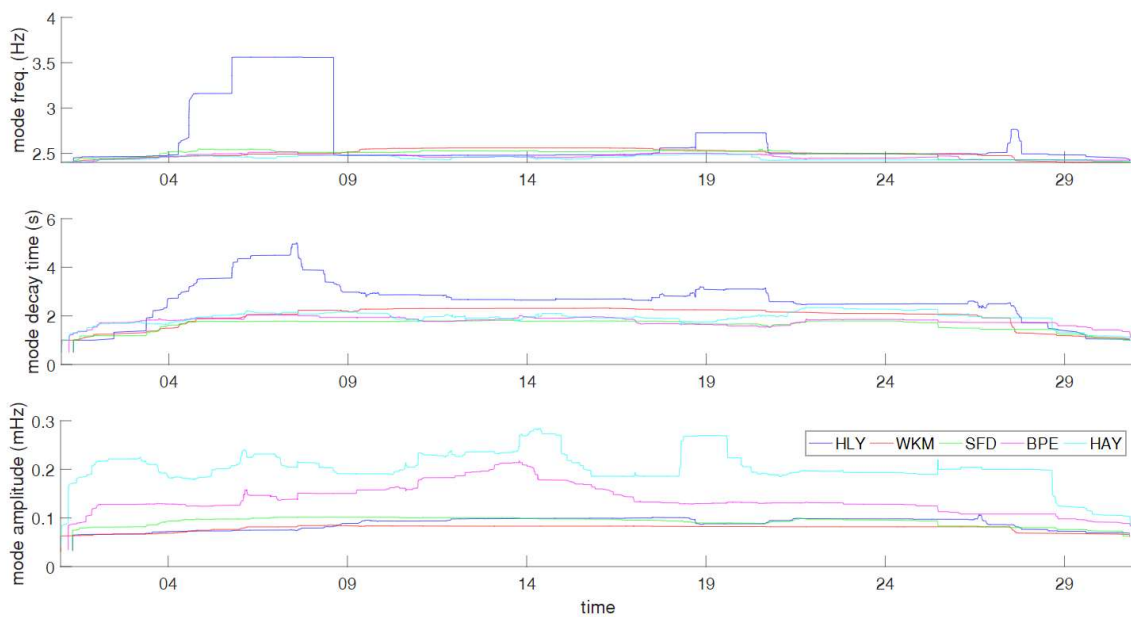


Figure 23: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

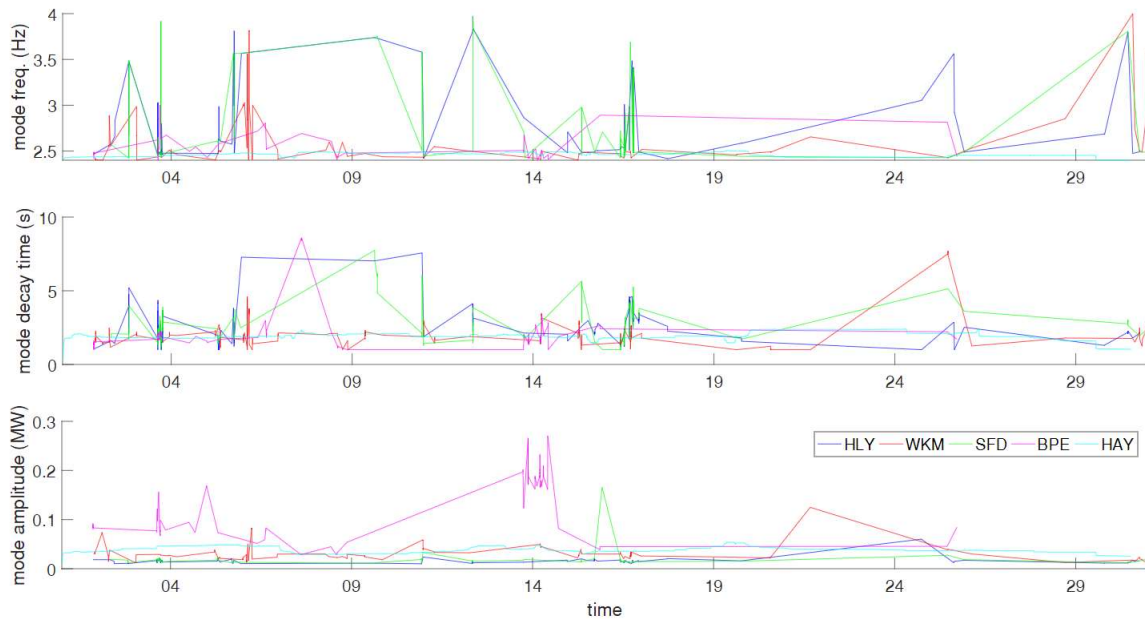


Figure 24: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

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

Using active power:

- Few data points are recorded for this mode band.
- All modes in this band appear well-damped and low magnitude in the power data.

The poorly damped mode around 2.4 Hz reported in the histogram data is observable in the raw data but is very low magnitude so is not reported in the trends – there were a few periods overnight where a mode near 2.4 Hz with long decay time was identified for up to several hours at Haywards and Bunnythorpe – e.g. this is one hour for the BPE frequency report at 2.31 Hz at 01:00 on 16th April

