DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – SEPTEMBER 2022

Transpower New Zealand Limited

September 2022

Keeping the energy flowing




TRANSPOWER

Version	Date	Change
1.0	24/01/2024	

	Position	Date
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Reviewed By:	Richard Sherry, Principal Engineer	24/01/2024

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 September 2022. This monthly report presents these findings for September 2022 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 September 2022
0.04 Hz	All-f	Governor modes	No significant change over the month Well-damped
0.25 Hz	All-f	Probably control modes, and not electro-mechanical	Relatively high number of occurrences Occurrences of low damping periods High decay time in certain periods
0.5 – 0.6 Hz	All-f All-p	Possibly Inter area modes	Decay time higher than 5s for a few periods
0.9 - 1 Hz	All-f All-p	Inter-area and Inter-station modes	Greater than 15s at times in power data Low amplitude
1.5-1.9 Hz	All-f All-p	Inter-station and Local modes	High number of occurrences Periods of relatively high amplitude
~2.4, 3, 3.5 Hz	WKM-f BPE-p	Not yet identified	Low number of occurrences Relatively well damped

3 Detailed plots for September 2022

3.1 Mode frequency histograms

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

3.1.1 PMU Frequency Data

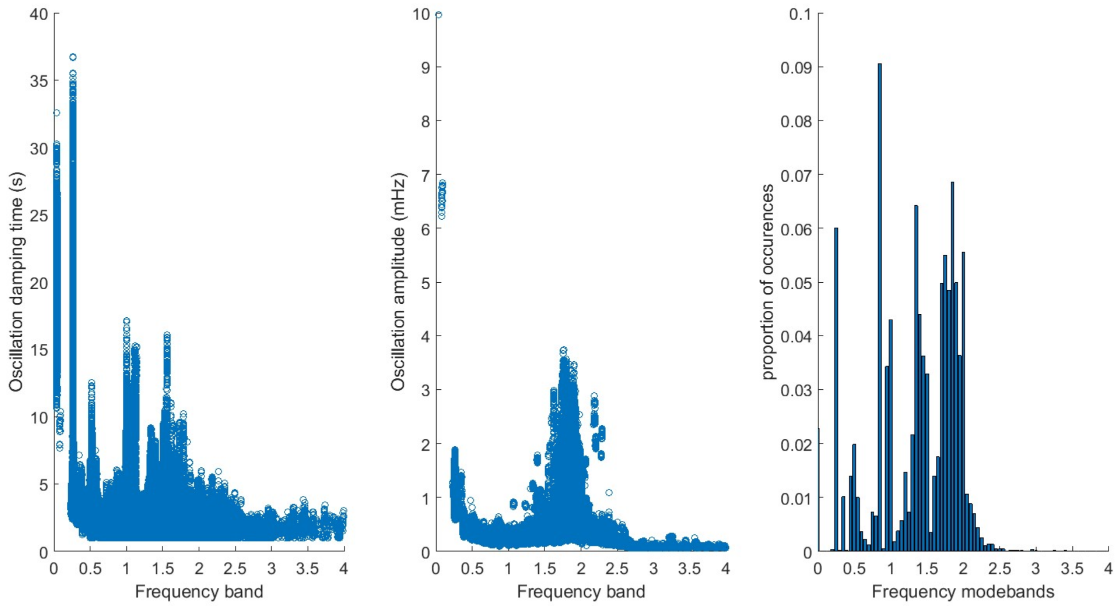

Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

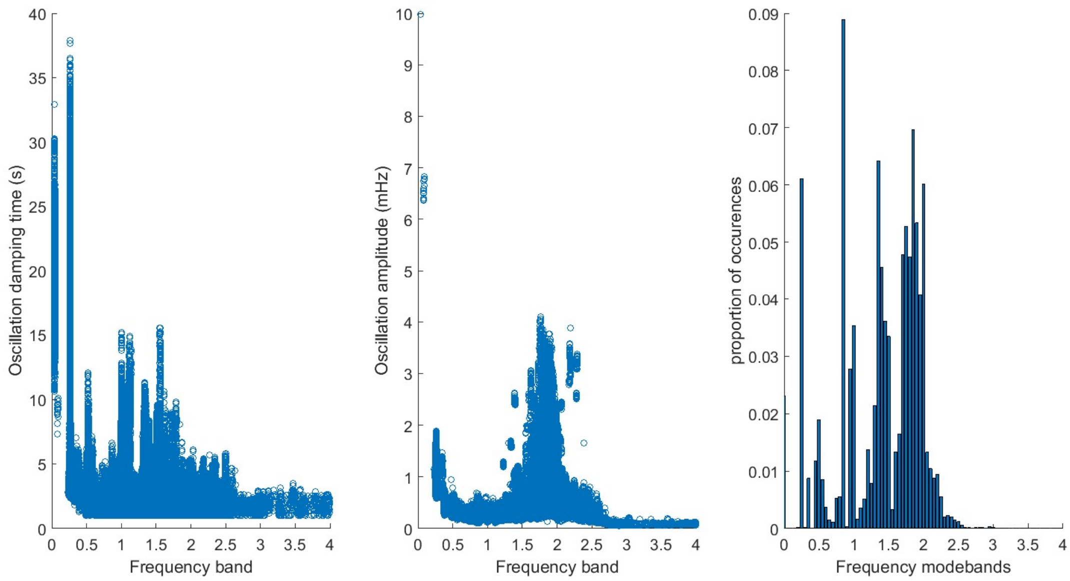

Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

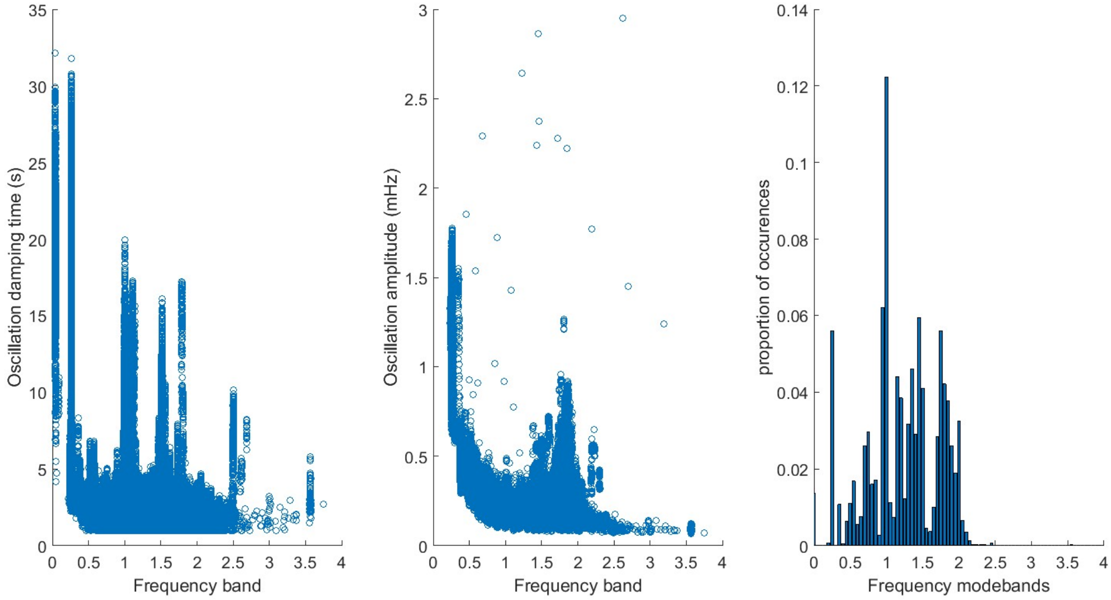

Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

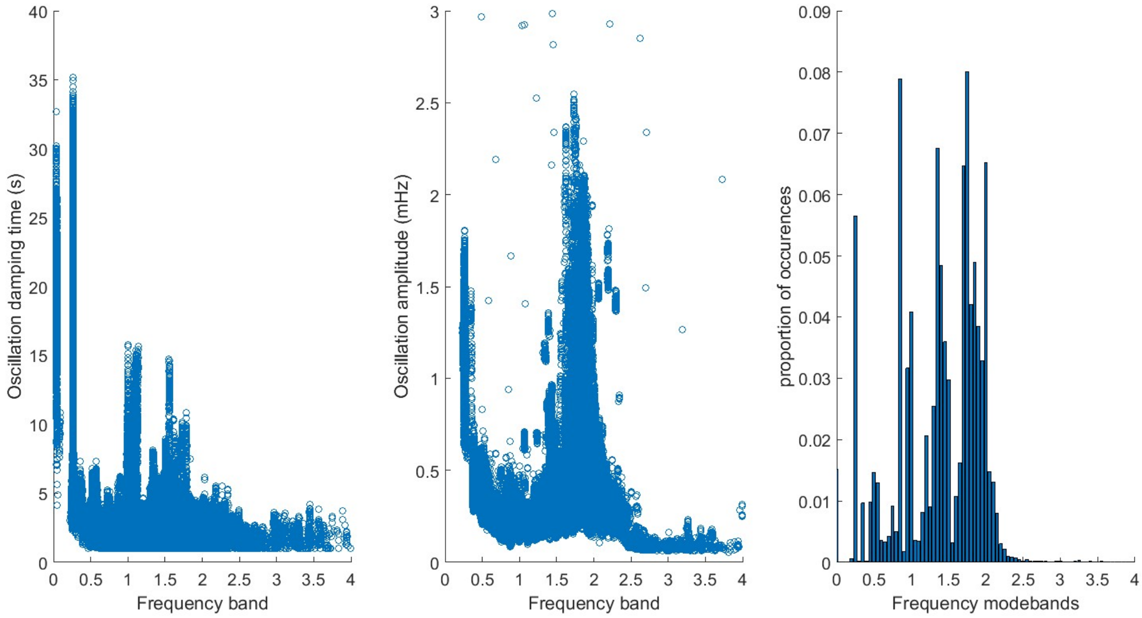

Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

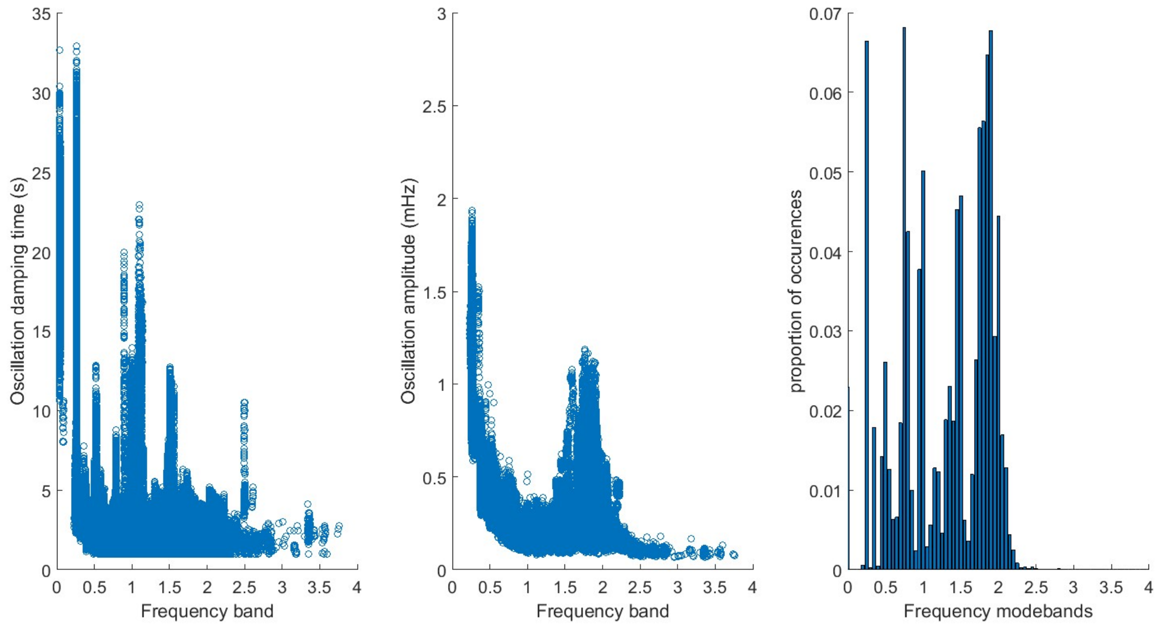

Figure 5: Wairakei mode damping, mode amplitude, and frequency histogram using frequency data

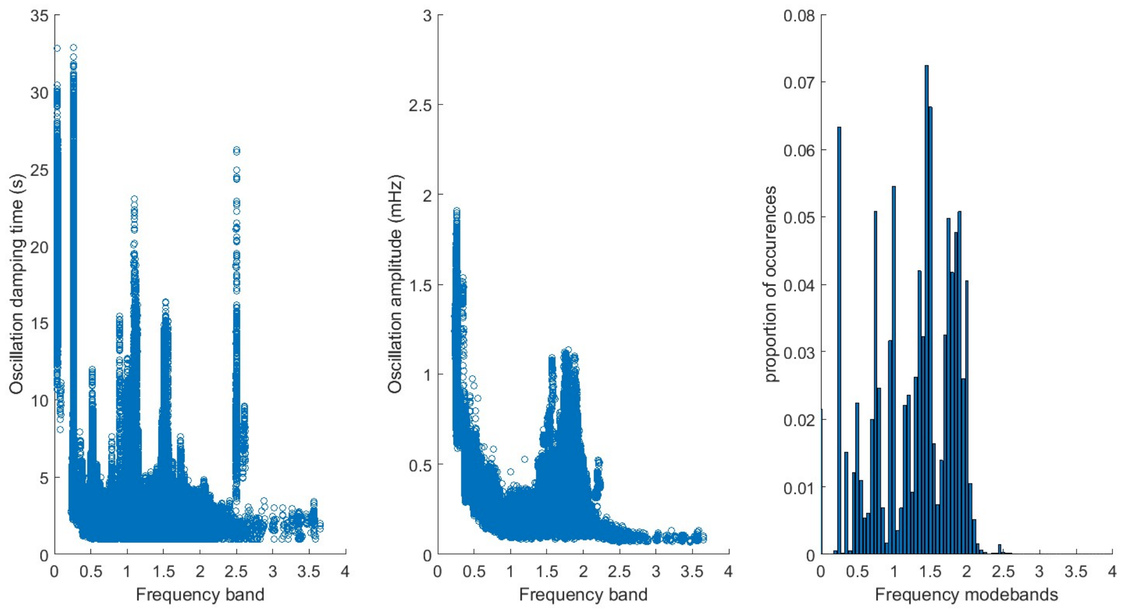

Figure 6: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

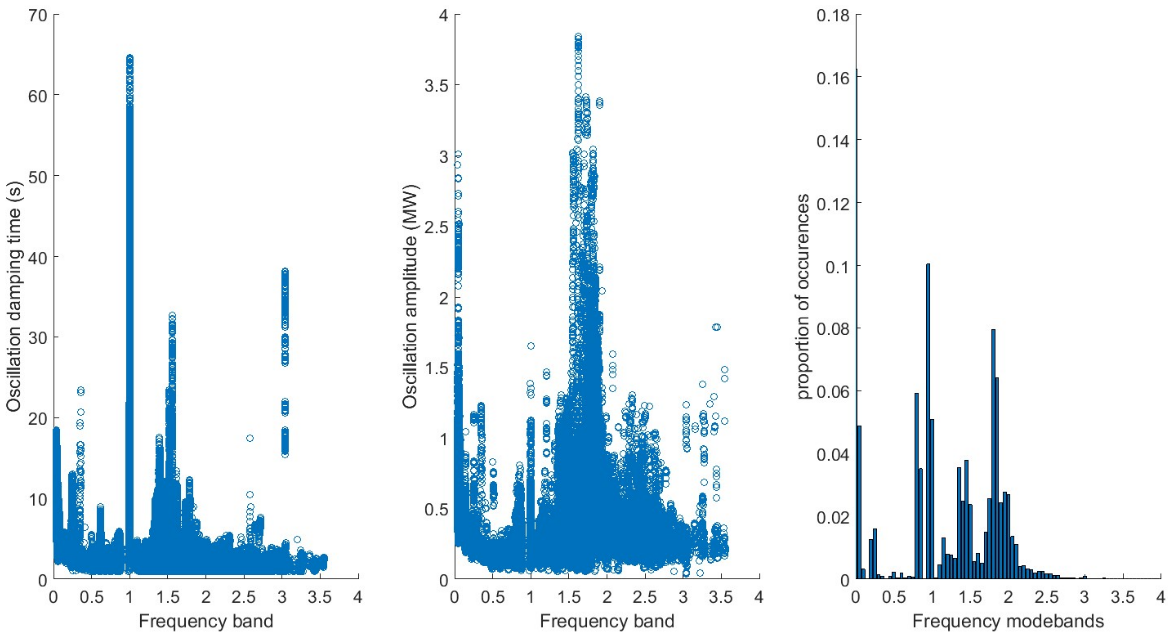

Figure 7: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

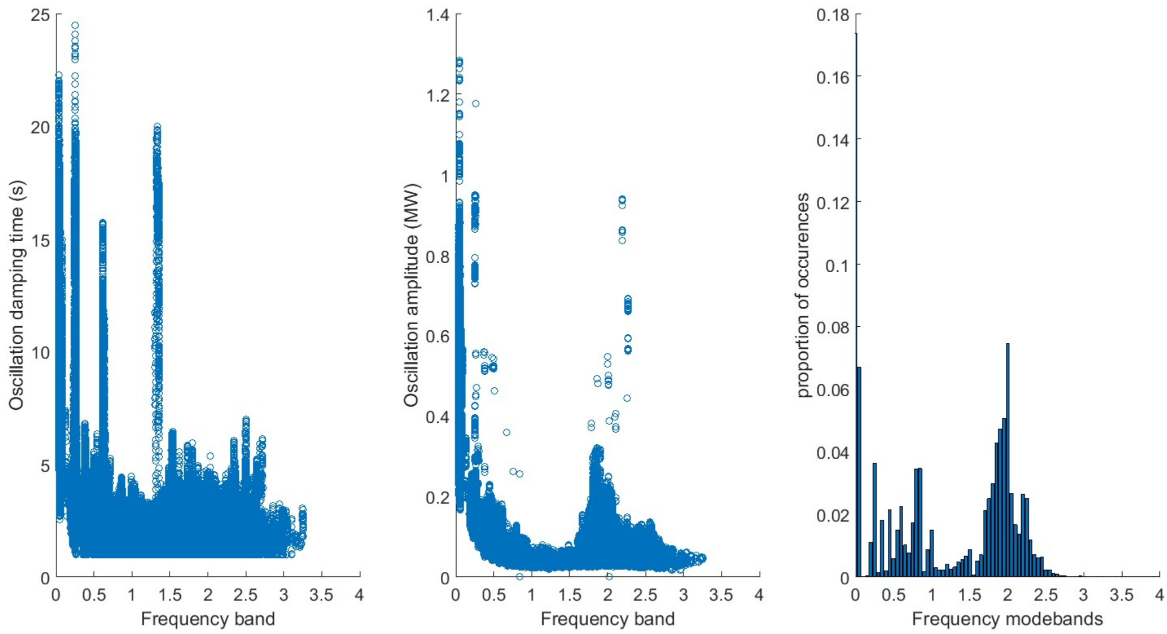

Figure 8: Haywards mode damping, mode amplitude, and frequency histogram using active power data

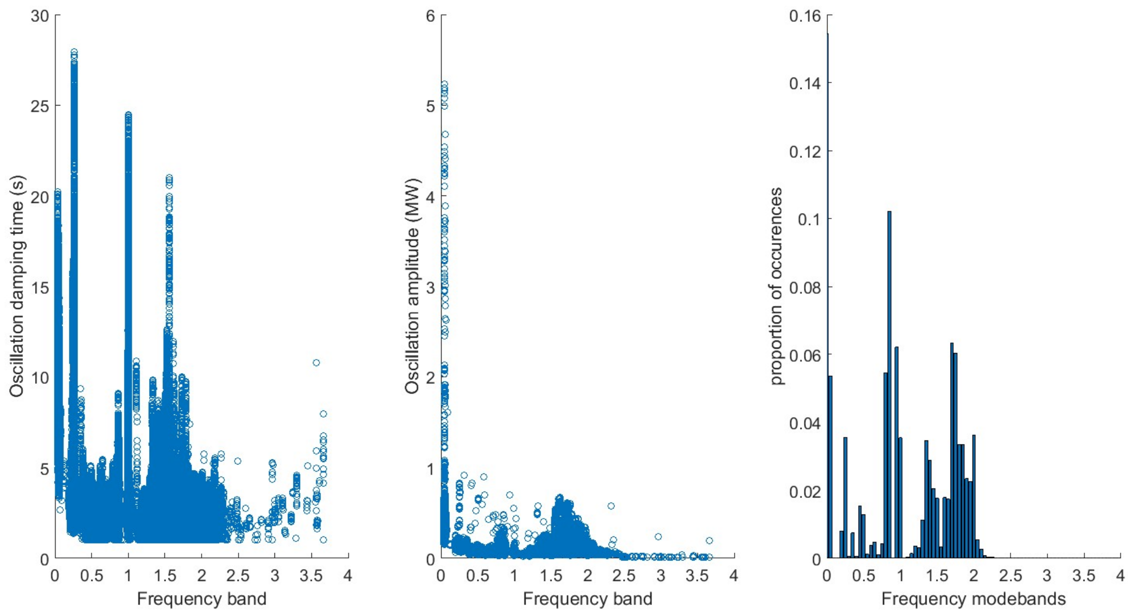

Figure 9: Huntly mode damping, mode amplitude, and frequency histogram using active power data

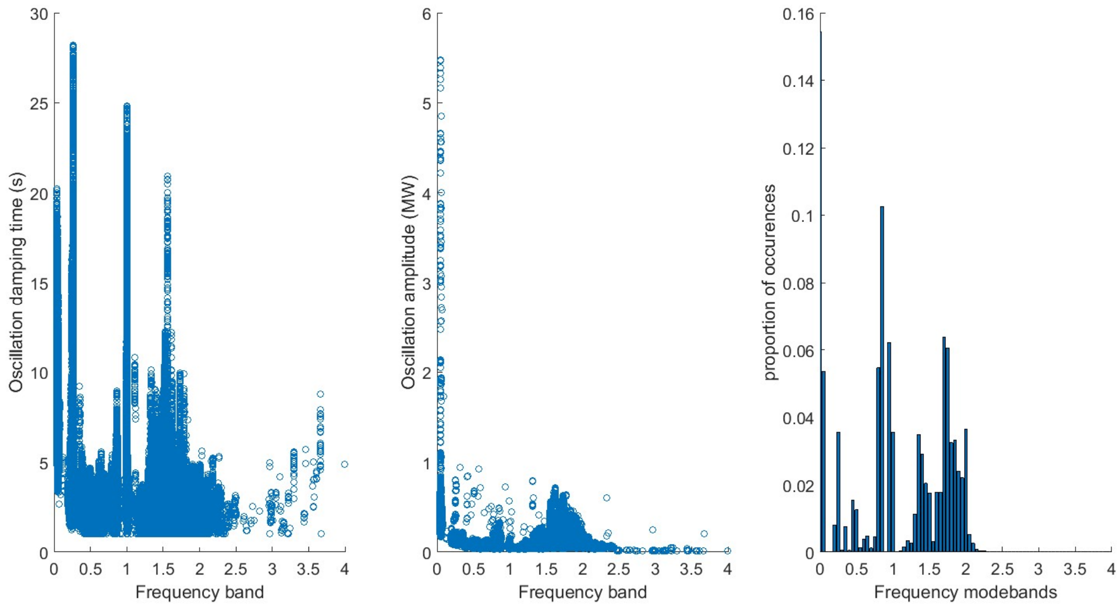

Figure 10: Stratford mode damping, mode amplitude, and frequency histogram using active power data

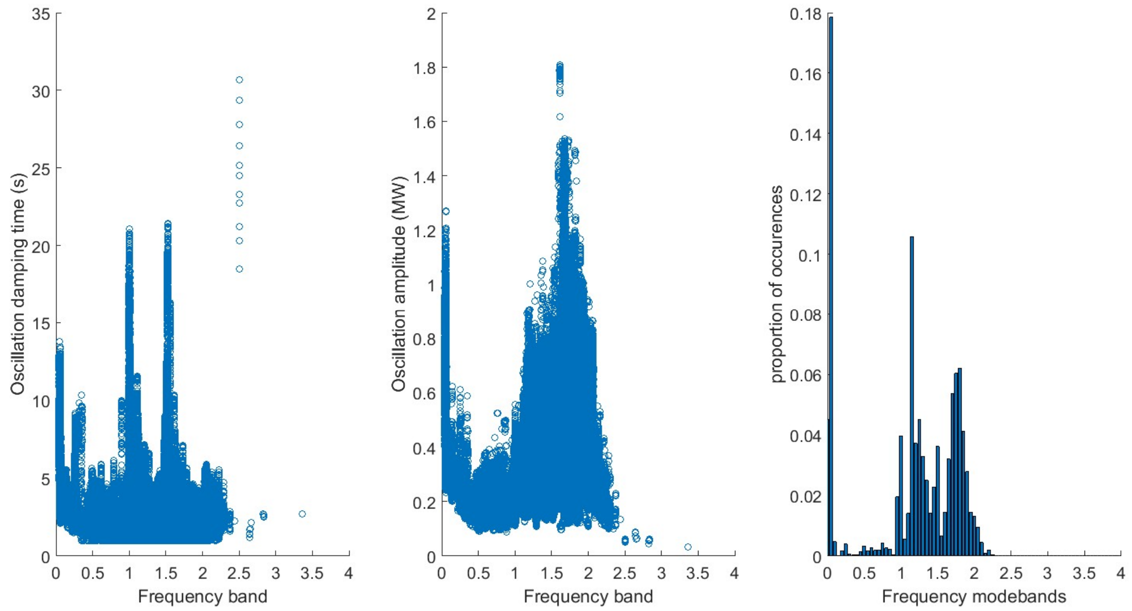

Figure 11: Wairakei mode damping, mode amplitude, and frequency histogram using active power data

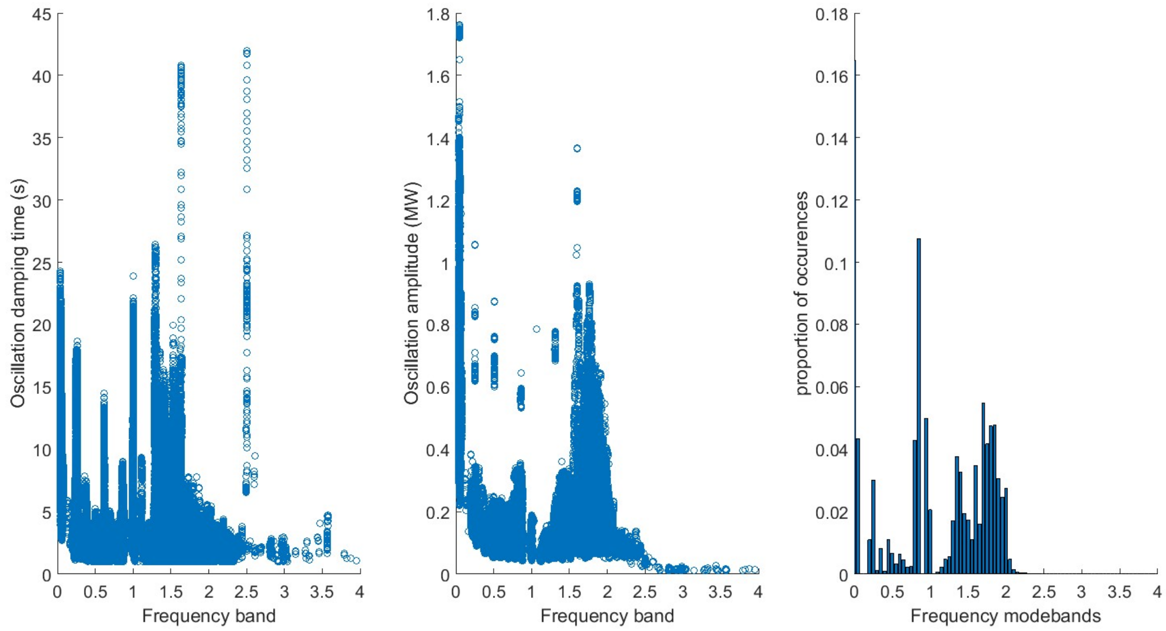

Figure 12: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

3.1.3 Observations using the frequency histograms

From the histograms, it can be observed that some modes have a large percentage of occurrences. One distinct mode at approximately 1.8 Hz can be observed in the September 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
- 1 Hz
- 1.5 Hz
- 1.8 Hz
- 2.5, 3 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

3.3 Mode band 1: [0.0 – 0.2 Hz]

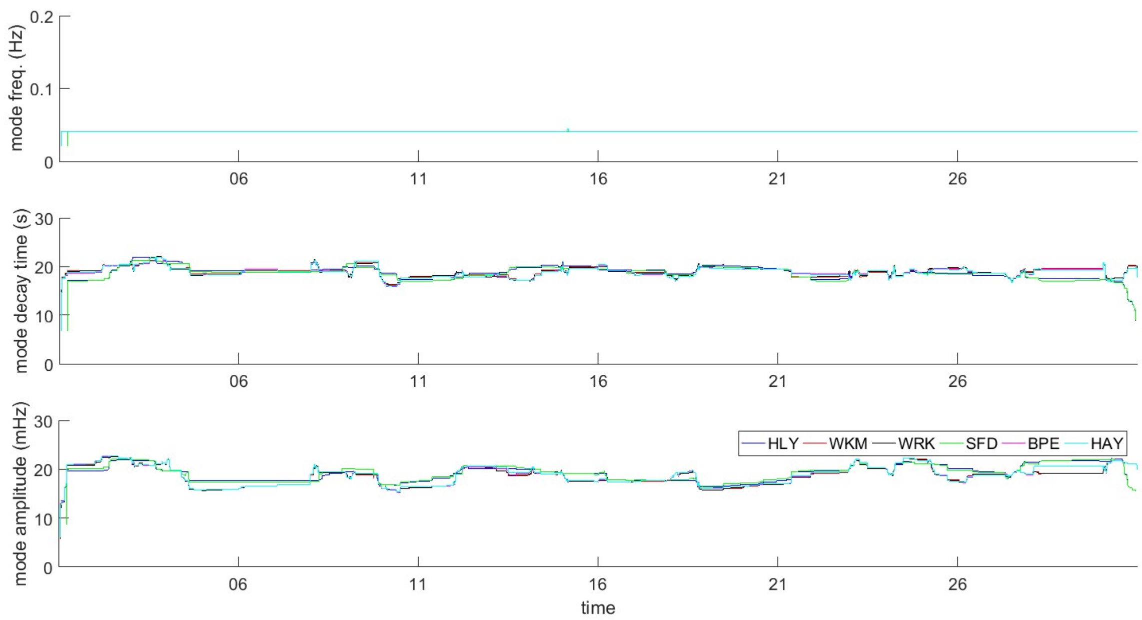

Figure 13: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

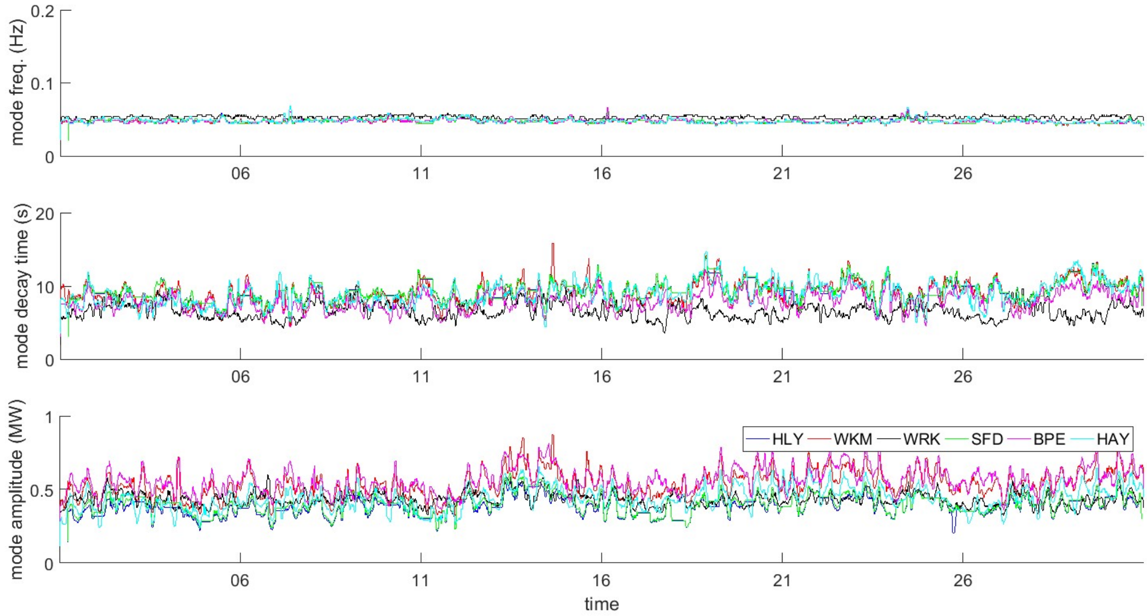

Figure 14: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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.

3.4 Mode band 2: [0.2 – 0.6 Hz]

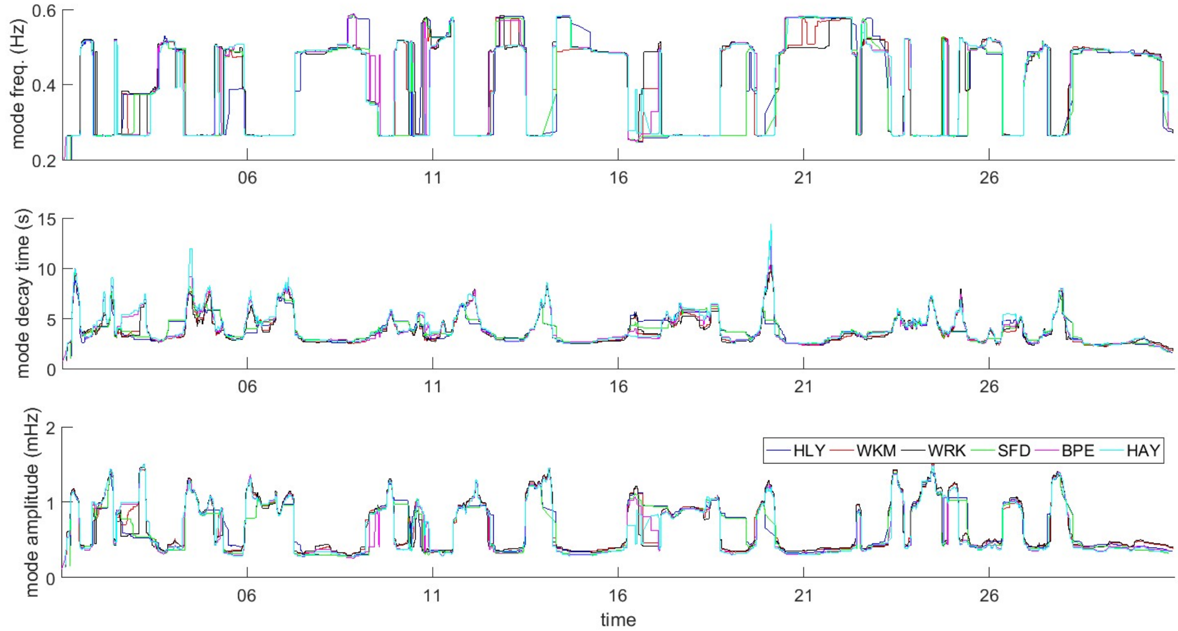

Figure 15: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

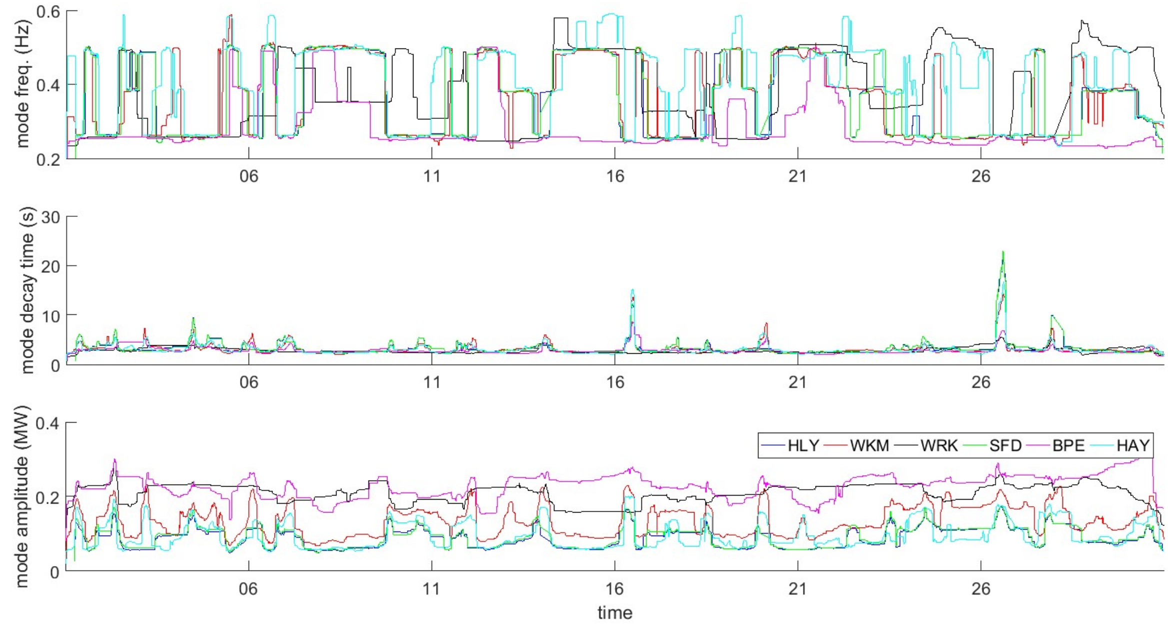

Figure 16: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency

- 0.25 Hz mode
  - Decay time around 5 seconds, increasing to 5-15 seconds at times throughout the month.
- 0.4 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 modes at most sites.
- 0.25 Hz mode decay time between 3-10 seconds, a peak decay of ~20 seconds observed at Stratford, Haywards and Huntly around 26th of September, but with low amplitude (< 300 kW) throughout.
- 0.5-0.6 Hz mode decay around 3 seconds when dominant.

3.5 Mode band 3: [0.6 – 0.9 Hz]

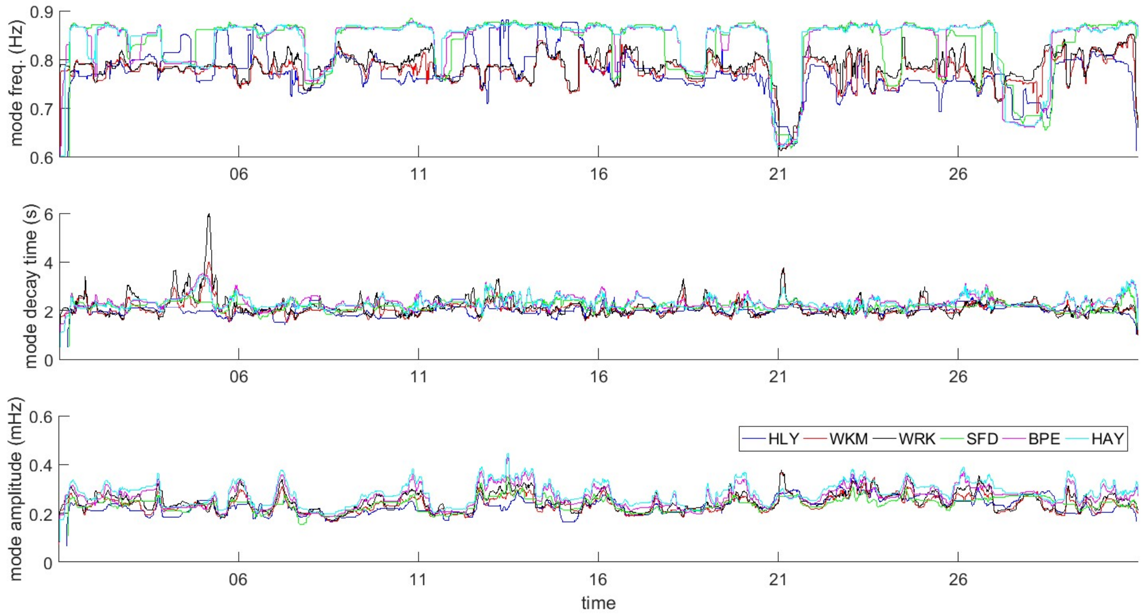

Figure 17: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

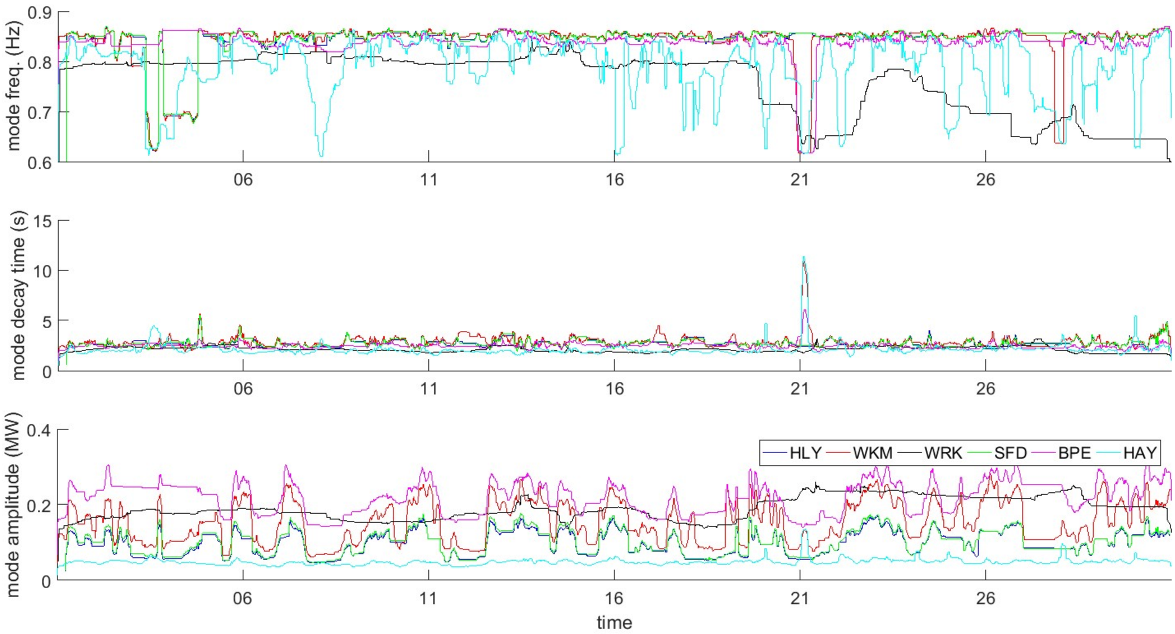

Figure 18: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Mode around 0.7 Hz – 0.9 Hz observed throughout the month, and a brief 0.6 Hz mode observed at all sites on 21st September.
- Decay time typically less than 5 seconds at most sites occasionally peaking as high as 6 seconds.
- Maximum amplitude ~0.4 mHz.

Using active power:

- Mode around 0.6 Hz – 0.85 Hz observable.
- Decay time less than 5 seconds at most sites, except for the 0.6 Hz mode with a 10 second decay time at Haywards and Whakamaru.
- Maximum amplitude at Bunnythorpe ~300 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

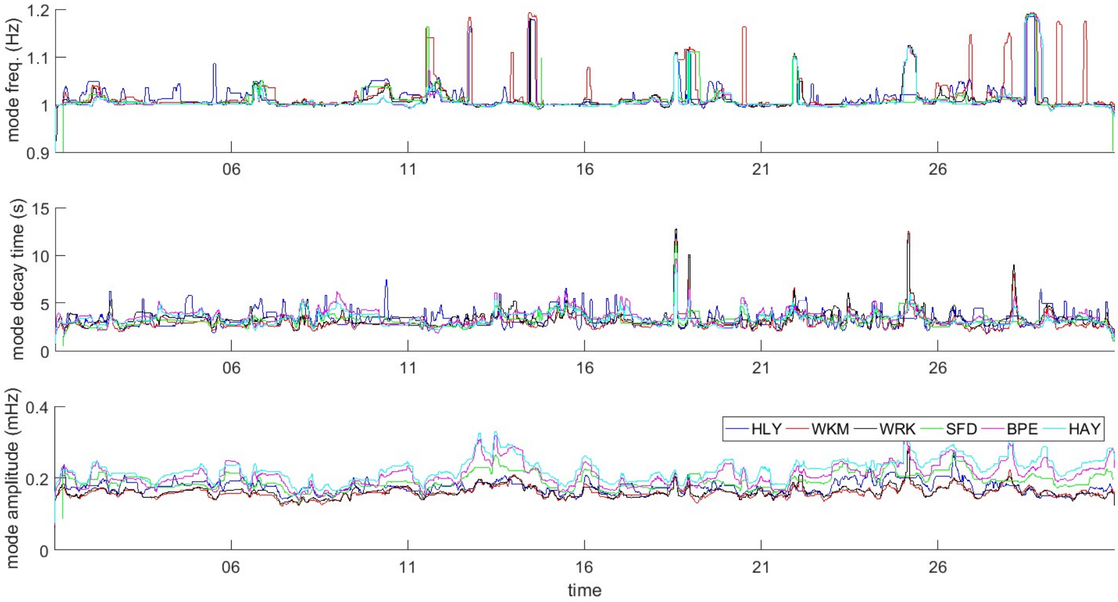

Figure 19: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

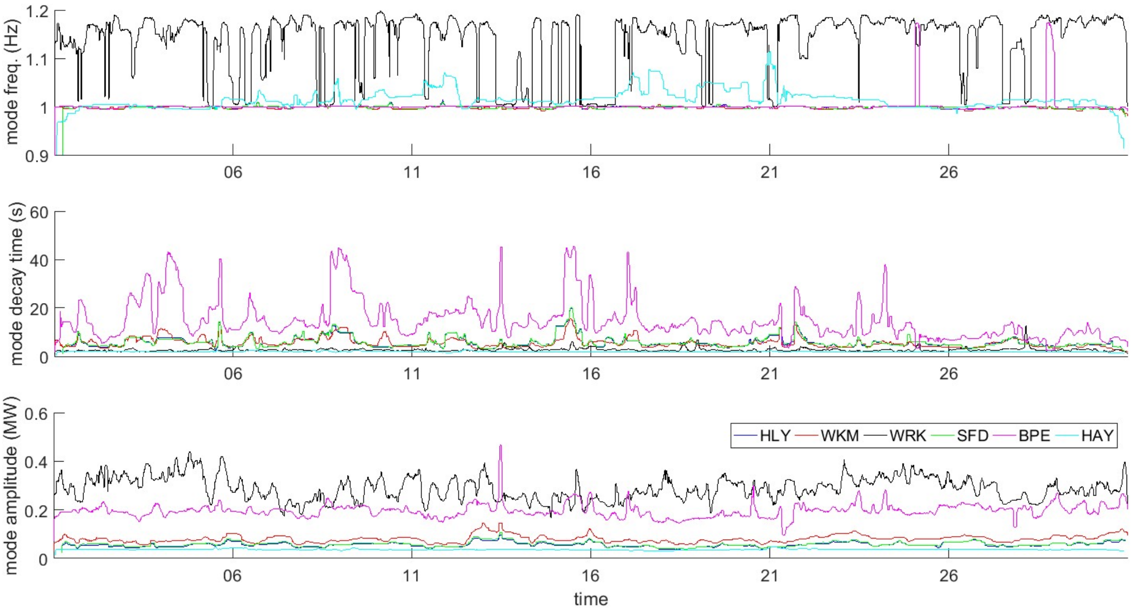

Figure 20: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at 1.00 Hz, 1.05 Hz, 1.1 Hz and 1.18 Hz.
- All decay times are under 15 seconds.
- Mode 1.1 Hz peaks around 12 seconds observed at certain periods.

Using active power:

- Mode 1.1 Hz exhibits decay time around 40 seconds observed at Bunnythorpe.
- Maximum oscillation amplitude is ~400 kW.

3.7 Mode band 5: [1.2 - 1.8 Hz]

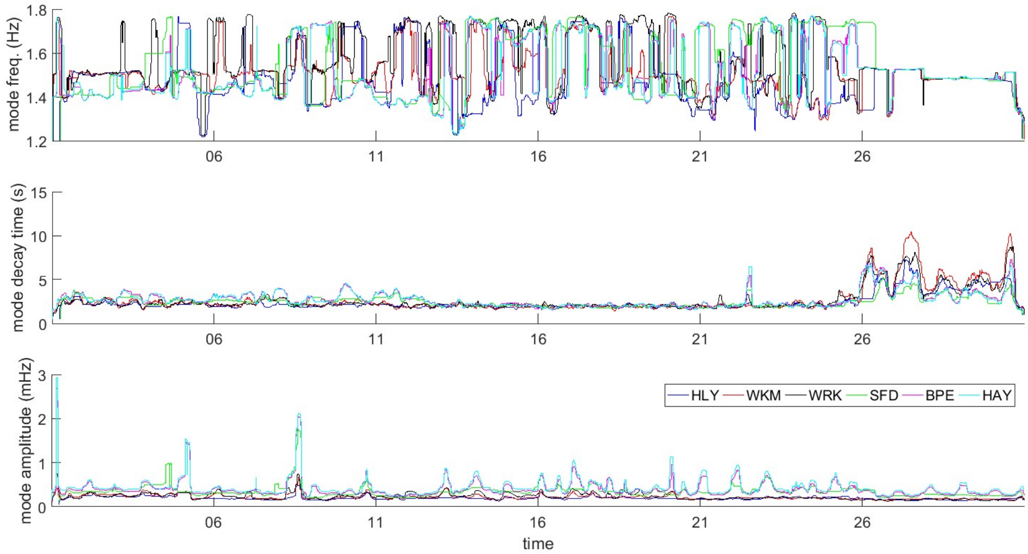

Figure 21: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

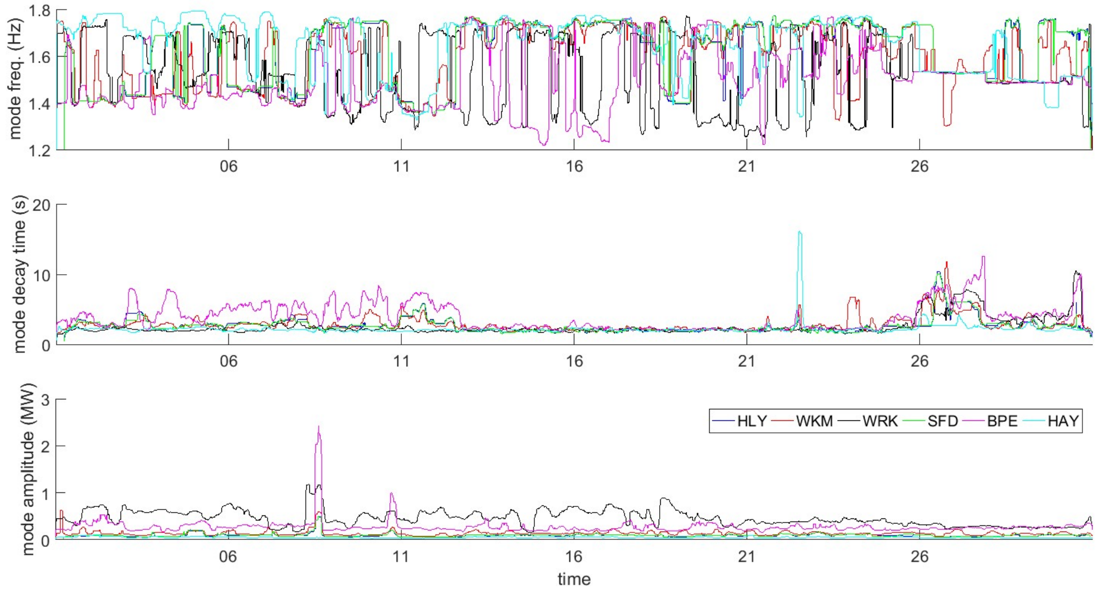

Figure 22: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes around ~1.2 Hz, ~1.5 Hz, and ~1.8 Hz.
- Maximum decay time ~10 seconds for any individual mode. Most of the month the decay time is less than 5 seconds for all modes.
- Maximum amplitude ~3 mHz observed at Haywards for ~1.8 Hz. Most mode amplitude was observed to be less than 0.5 mHz throughout the month.

Using active power

- Most modes appear to be relatively well damped except for a peak decay time of ~15 seconds at Haywards for ~1.4 Hz.
- Maximum amplitude ~2.5 MW observed for 1.7 Hz at Bunnythorpe however appeared relatively well damped.

3.8 Mode band 6: [1.8 – 2.4 Hz]

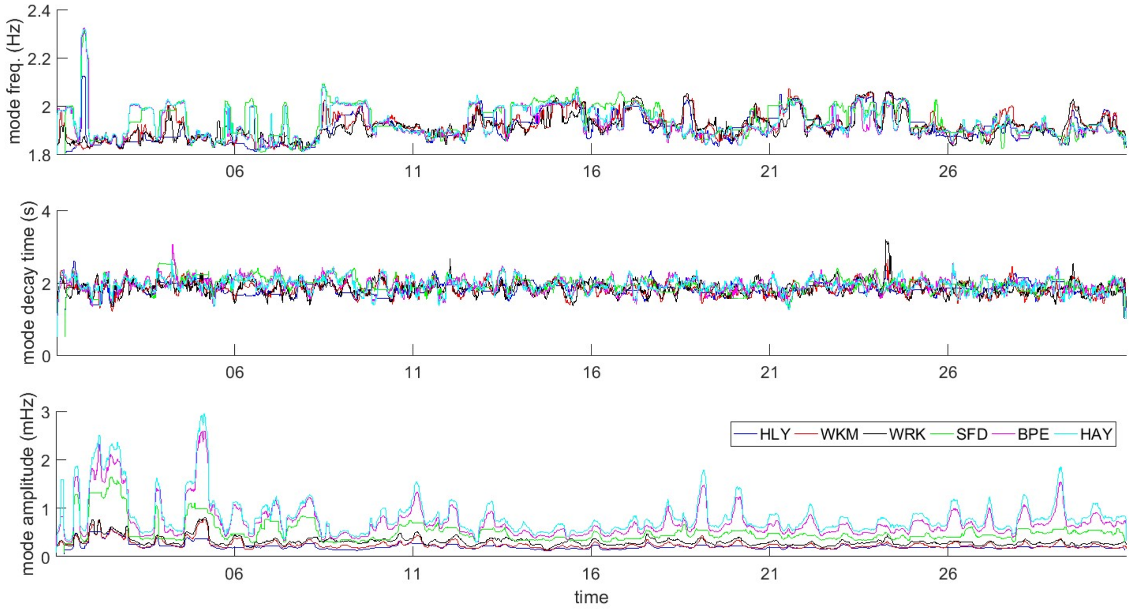

Figure 23: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

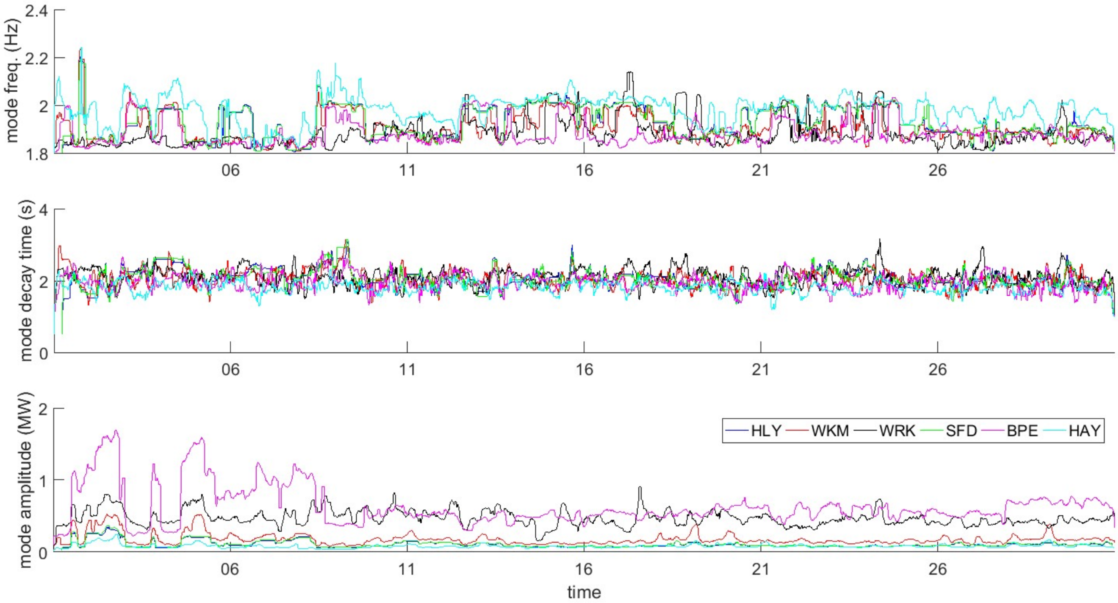

Figure 24: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- All modes in this band are relatively well-damped.

- Mode 2 Hz decay time peaked at around 3 seconds later in the month.

Using active power

- All modes in this band are relatively well-damped.
- Maximum oscillation amplitude for this mode band ~1.5 MW particularly visible at Bunnythorpe at the start of the month.

3.9 Mode band 7: [2.4 – 4 Hz]

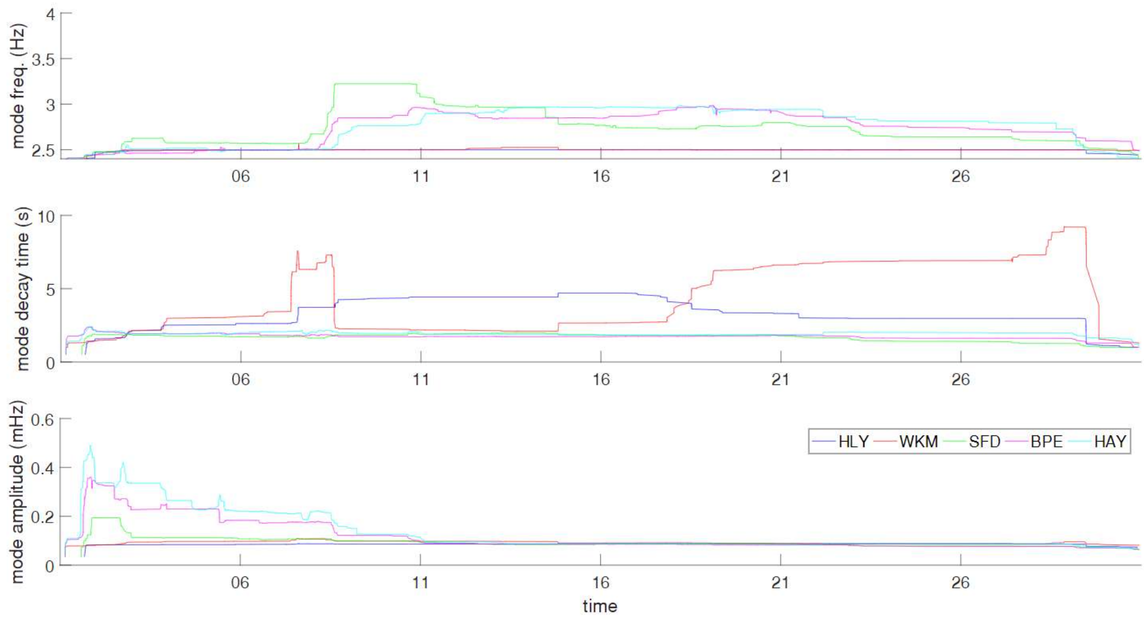

Figure 25: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

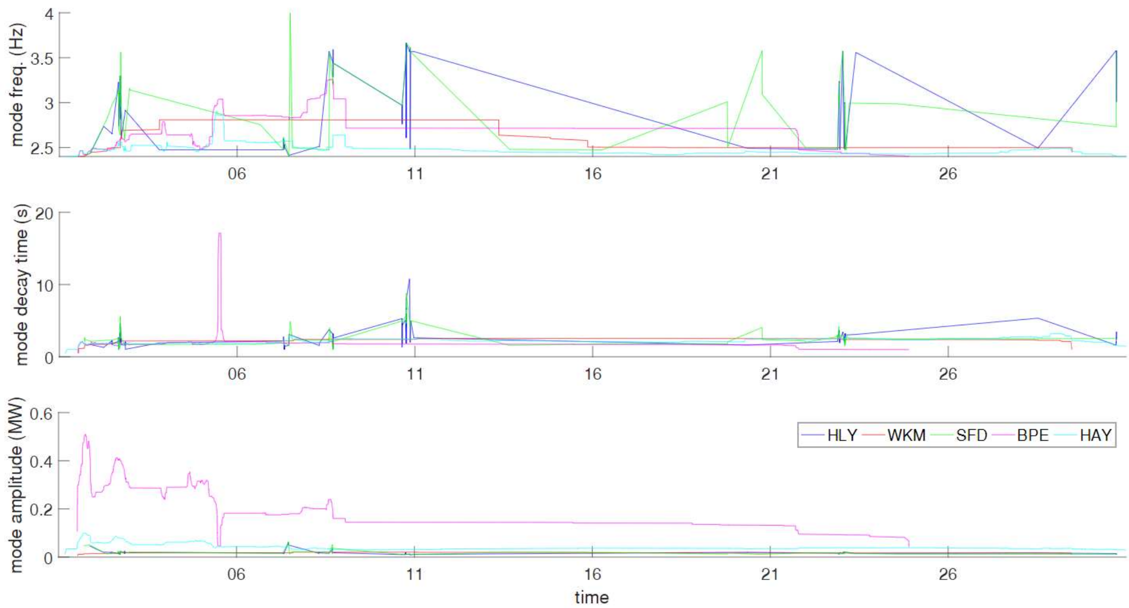

Figure 26: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Fewer data points are observed in this range. Modes observed at 2.5 Hz and ~3 Hz. All modes in this band are relatively well-damped.

Using active power:

- Mode observed at 3 Hz at Bunnythorpe reporting had a maximum decay time of 17 seconds very briefly, mostly well under 3 seconds.
- Maximum oscillation amplitude for this mode band ~500kW, visible at Bunnythorpe.