DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – JUNE 2022

Transpower New Zealand Limited

June 2022

Keeping the energy flowing

TRANSPOWER

Transpower New Zealand Limited The National Grid

NOTICE

Version	Date	Change
1.0		Final

	Position	Date
Prepared By:	Jessie Fahey, Power Systems Engineer	19/10/2023
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 June 2022. This monthly report presents these findings for June 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 June 2022
0.04 Hz	All-f All-p	Governor modes	Low number of occurrences in frequency data Low damping and high number of occurrences in detailed power data No significant change over the month
0.25 Hz	All-f	Probably control modes, and not electro-mechanical	High decay time Relatively high number of occurrences
0.5 – 0.6 Hz	All-f Most-p	Possibly Inter area modes	Typically well damped
0.7-0.9 Hz	All-f All-p	Inter-area and Inter-station modes	Periods of high decay time Greater than 30s at times in power data High number of occurrences
1.7-1.9 Hz	All-f All-p	Inter-station and Local modes	High number of occurrences
2.4, 3, 3.5 Hz	All-p, SFD-f, HLY-f	Not yet identified	Low number of occurrences Well damped

3 Detailed plots for June 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

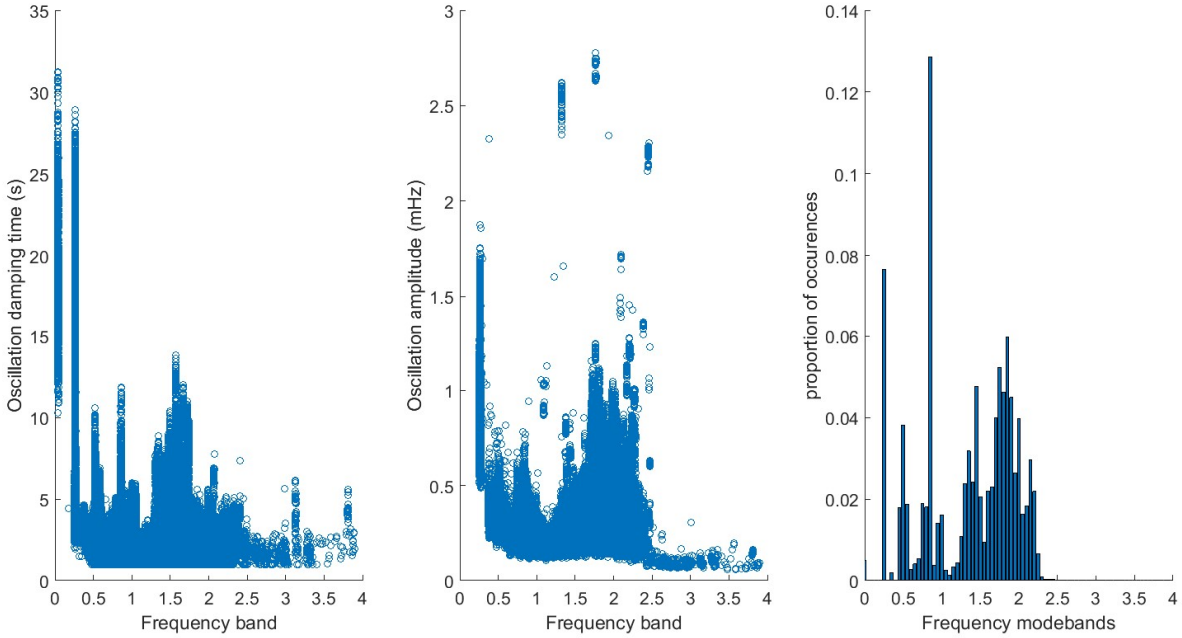

Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

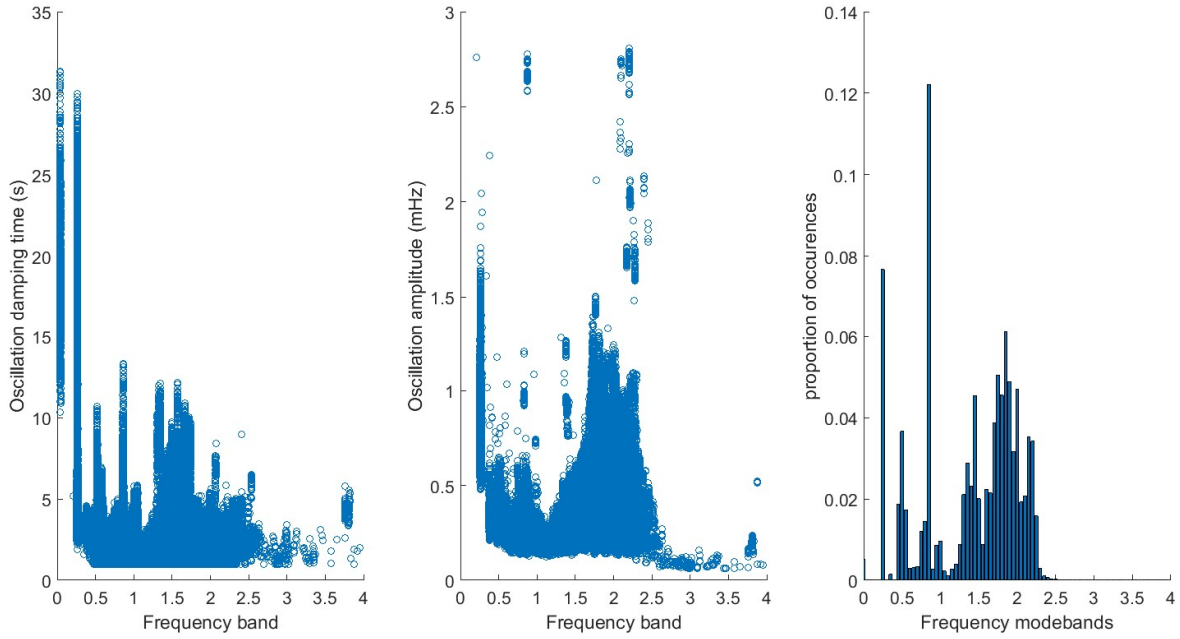

Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

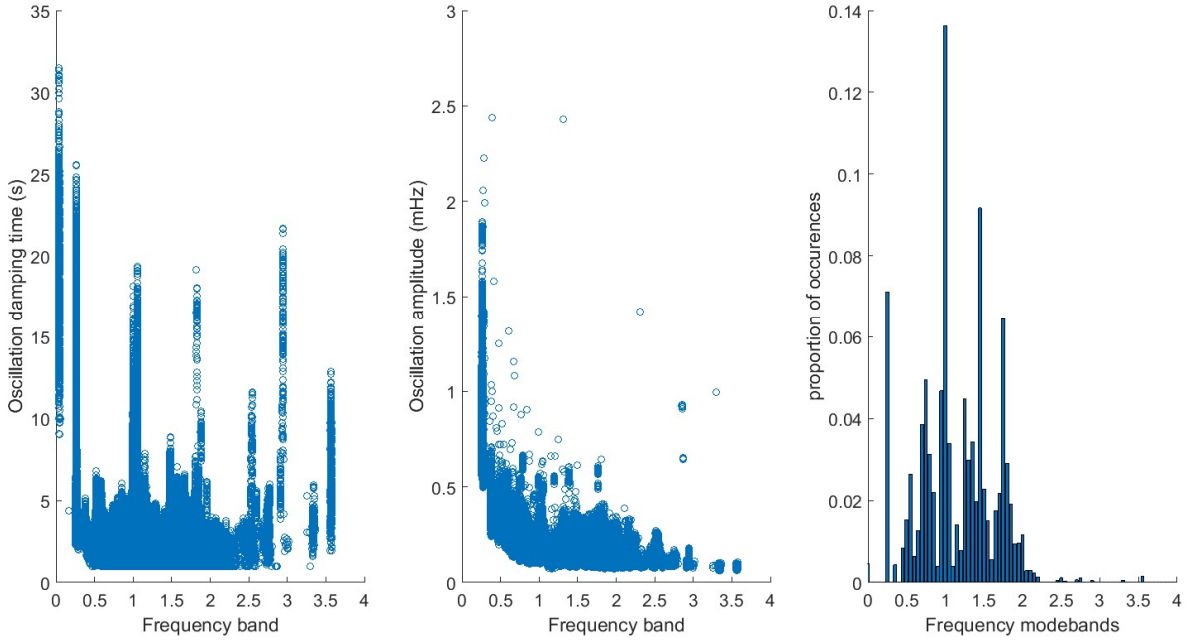

Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

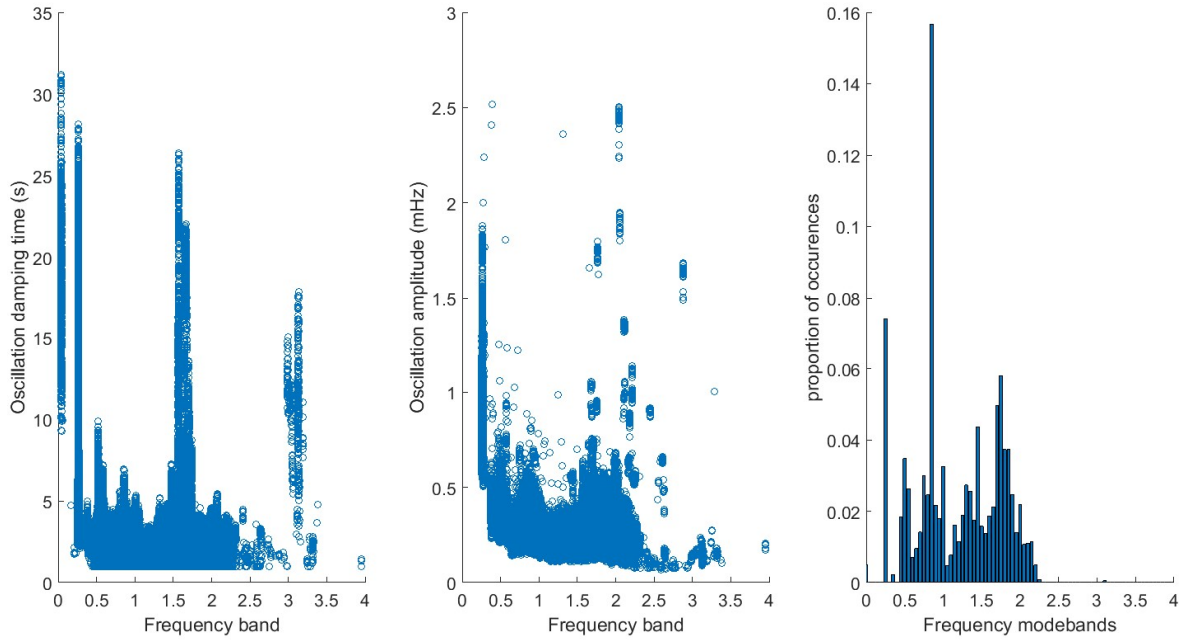

Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

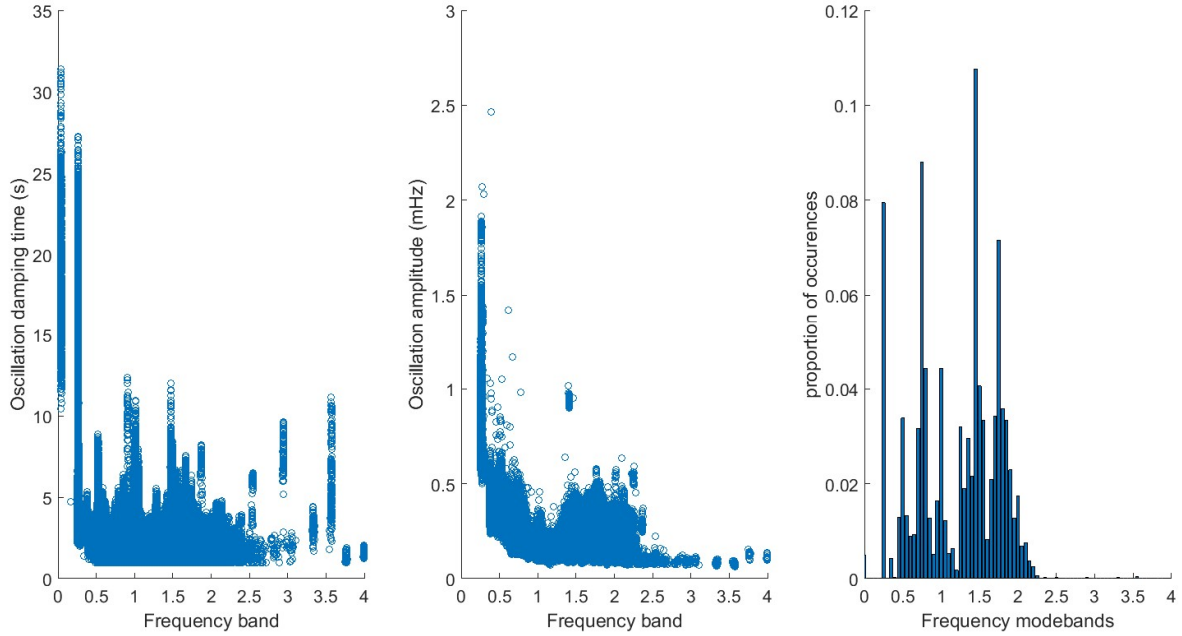

Figure 5: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

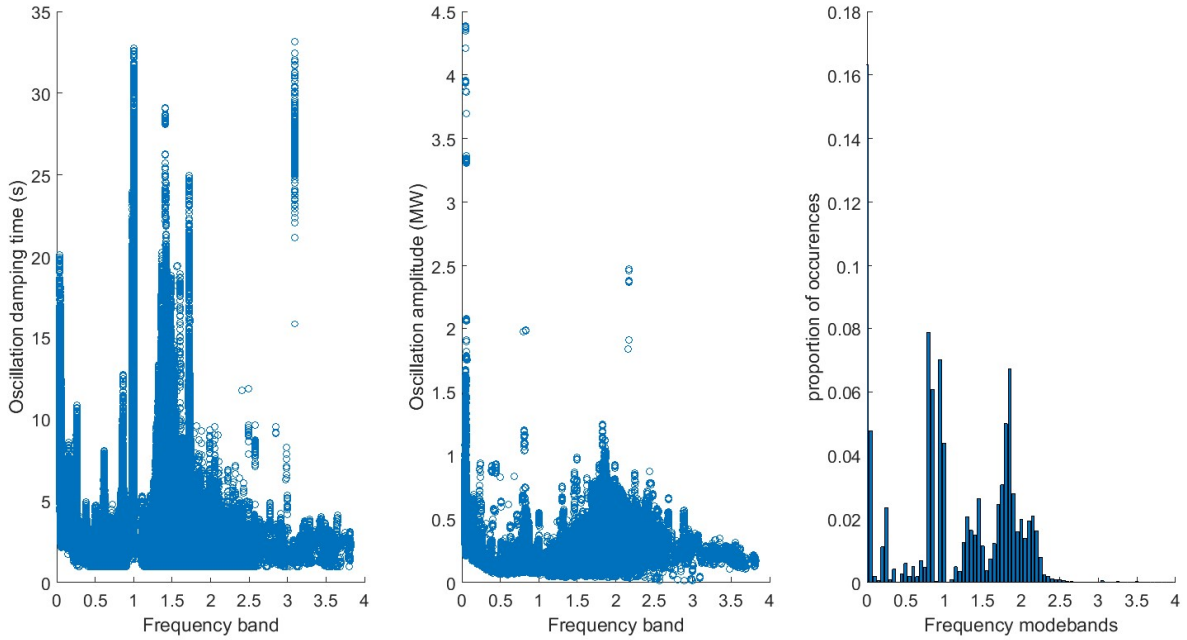

Figure 6: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

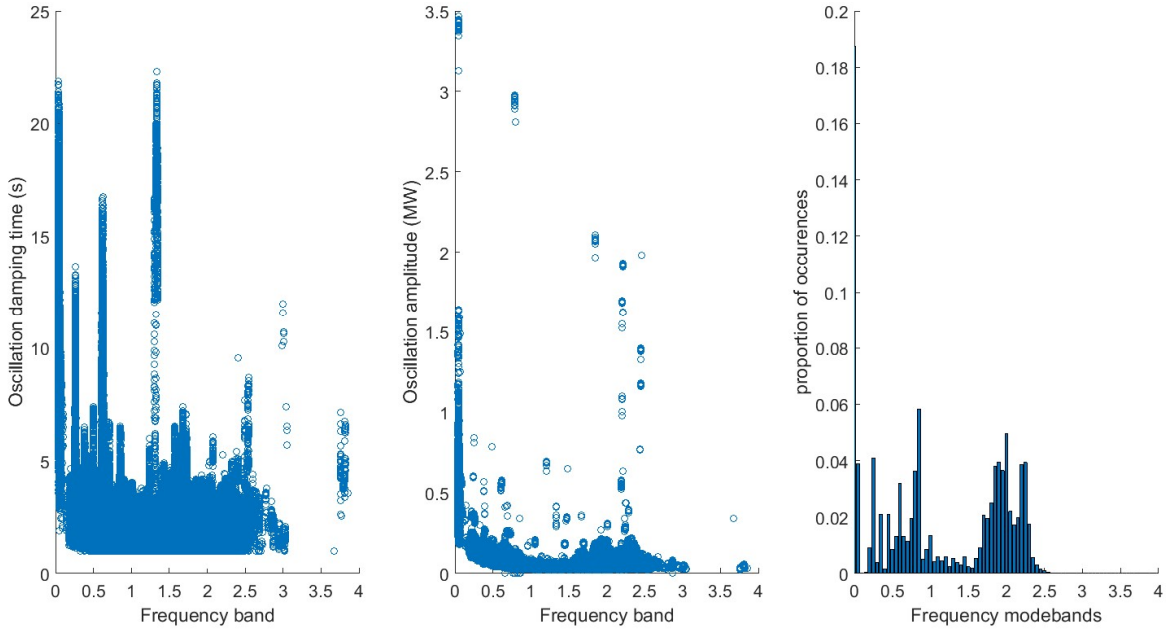

Figure 7: Haywards mode damping, mode amplitude, and frequency histogram using active power data

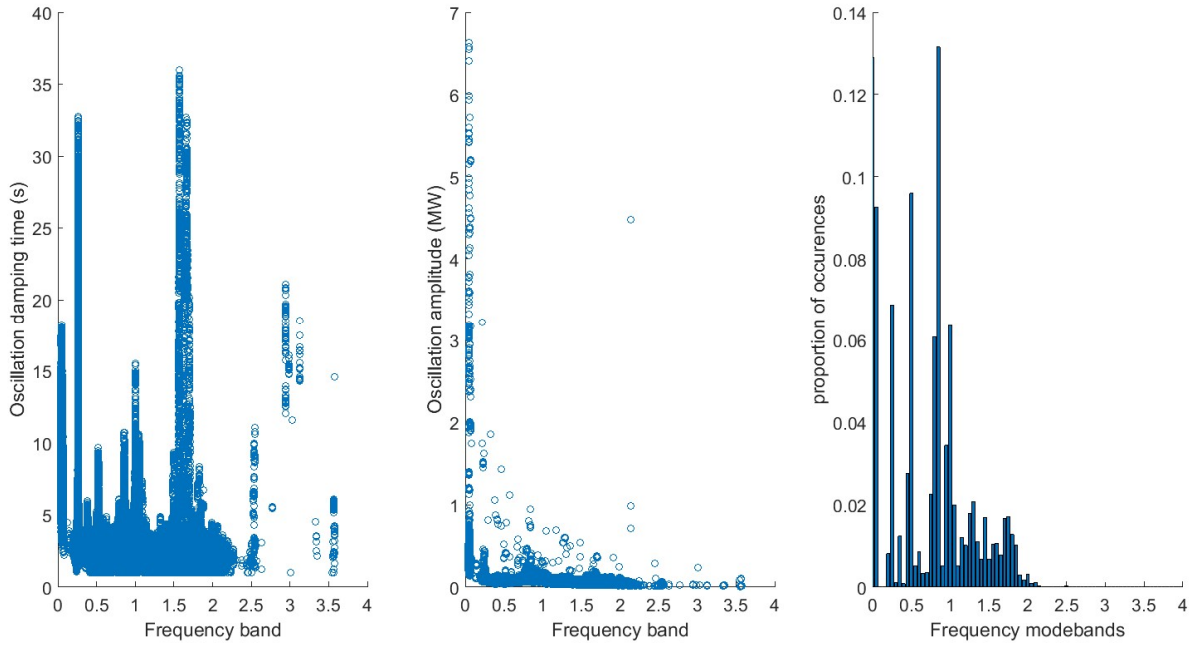

Figure 8: Huntly mode damping, mode amplitude, and frequency histogram using active power data

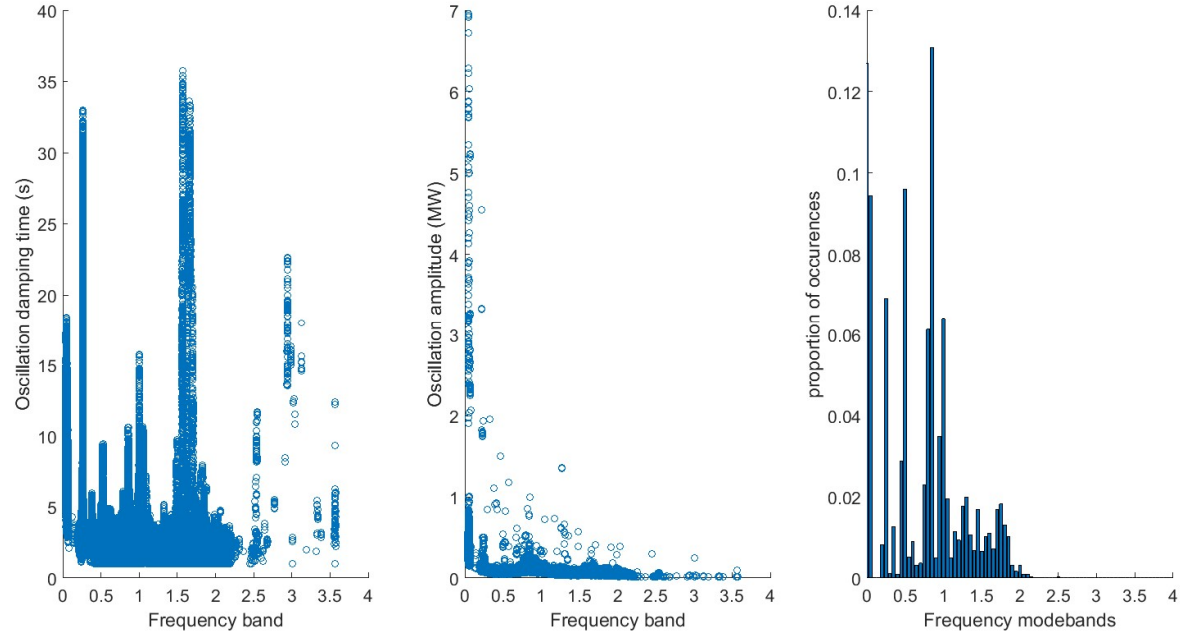

Figure 5: Stratford mode damping, mode amplitude, and frequency histogram using active power data

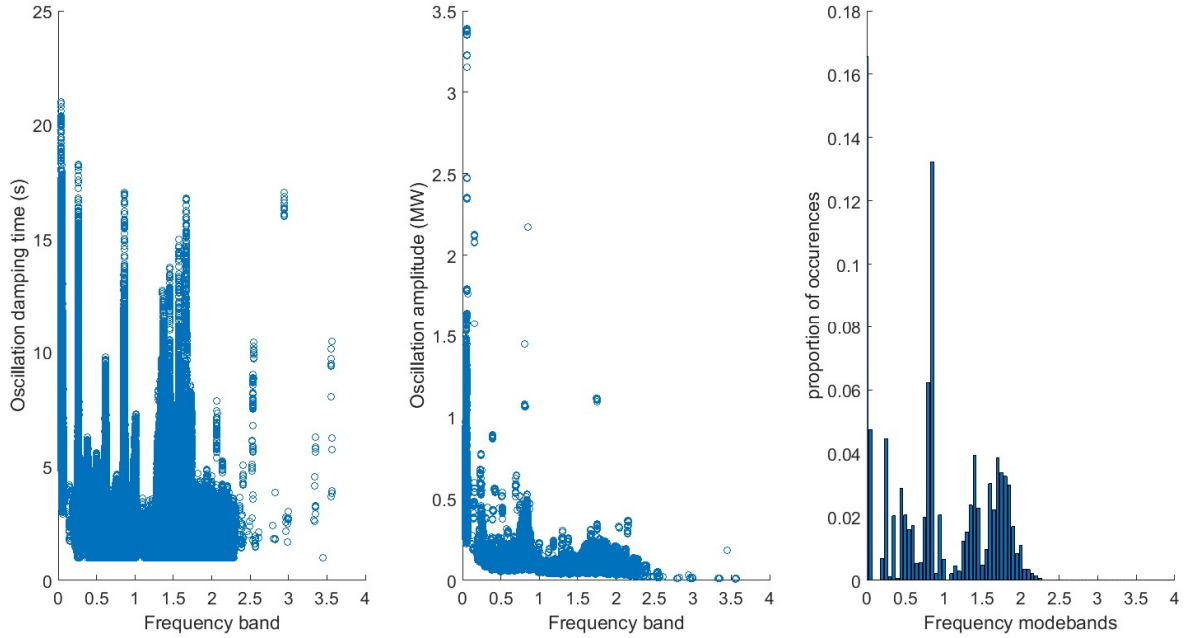

Figure 60: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

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 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
- 0.9 Hz
- 1.45 Hz
- 1.8 Hz
- 2.5, 3, 3.5 Hz

Outages around BPE and LTN are a contributing factor in the high oscillation amplitude observed around 1.8/1.9 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

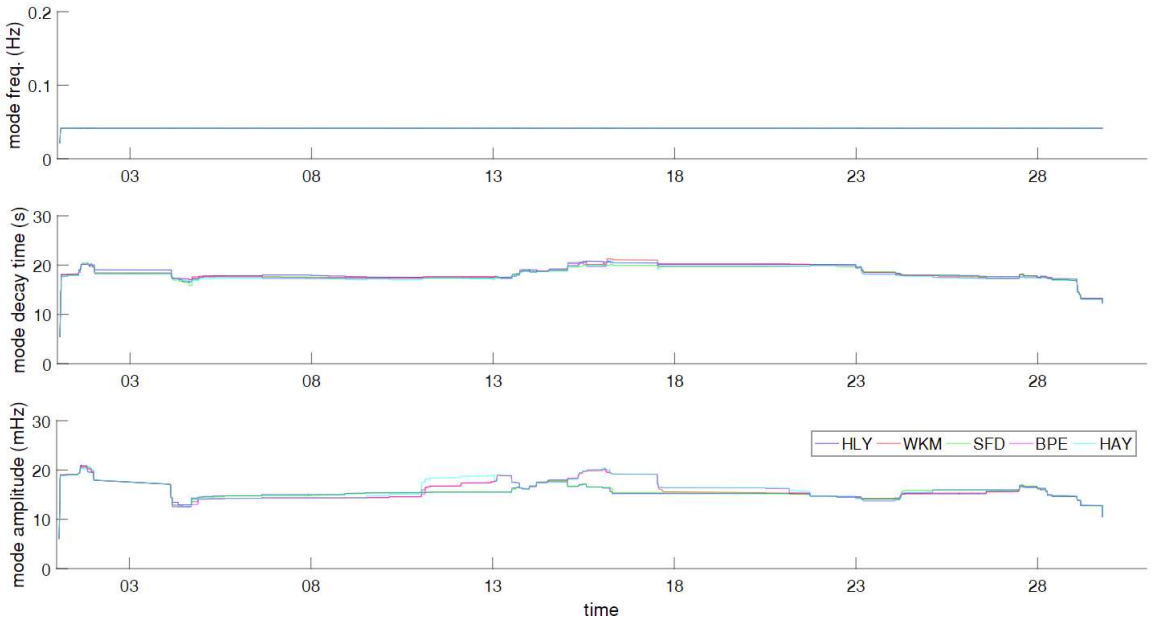

Figure 71: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

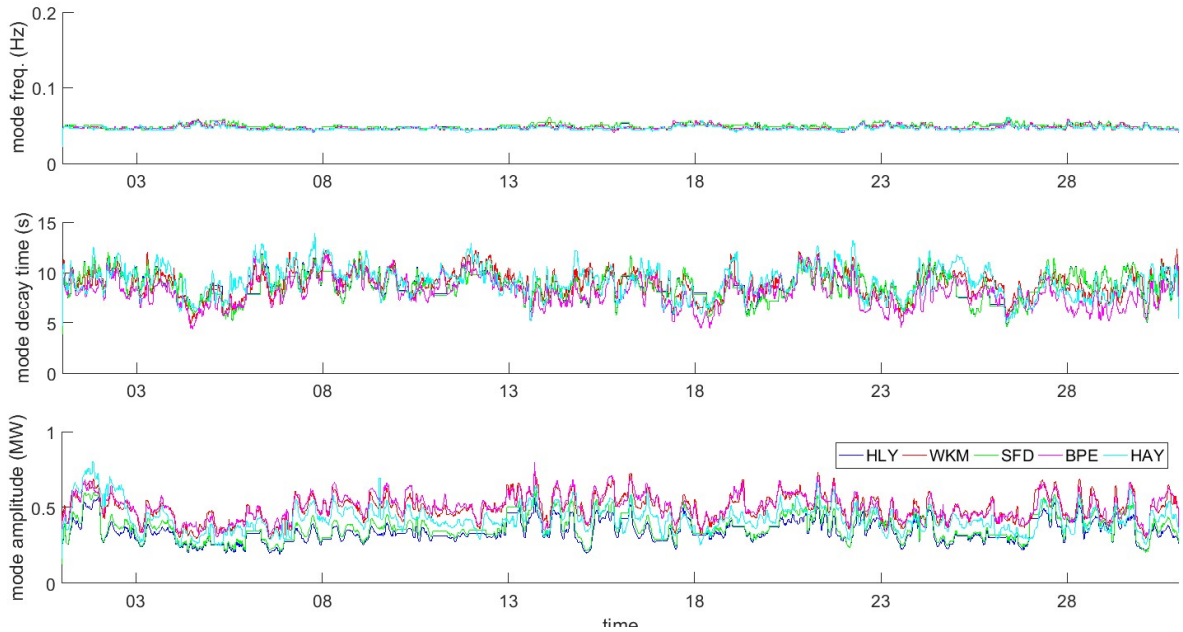

Figure 82: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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.
- Maximum oscillation amplitude ~20 mHz.

Using active power:

- 0.05 Hz mode observed at all substations.
- Decay time typically at 9 seconds for all substations, with a minimum of 5 seconds at BPE and a maximum of 14 seconds at Haywards.
- Maximum oscillation amplitude ~750 kW.

3.4 Mode band 2: [0.2 – 0.6 Hz]

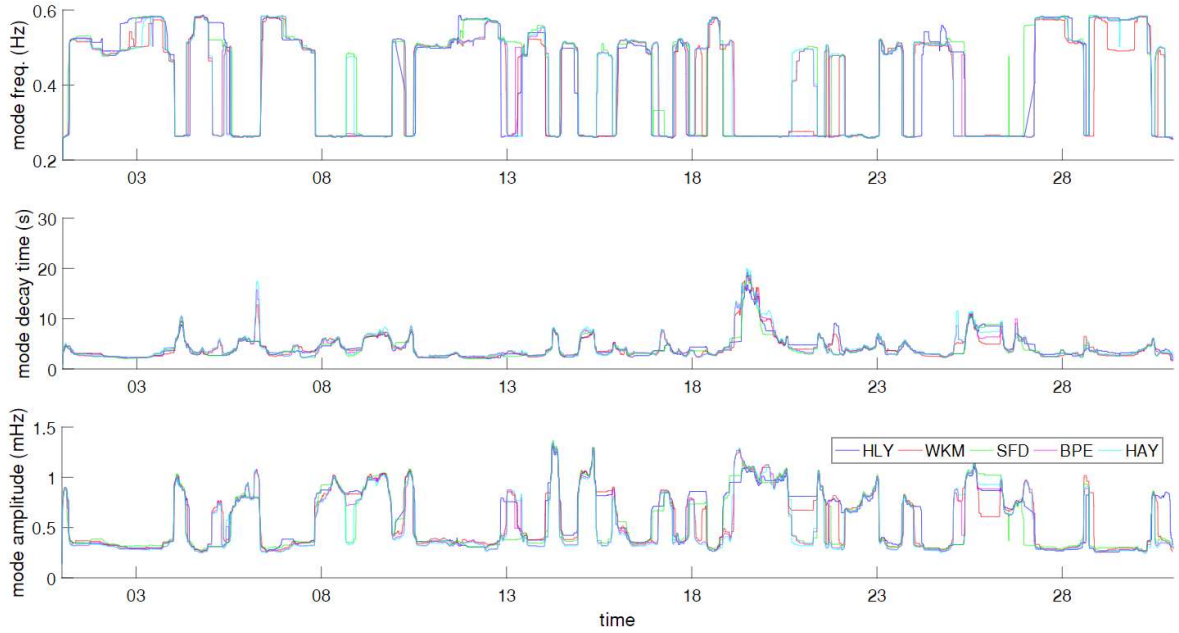

Figure 93: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

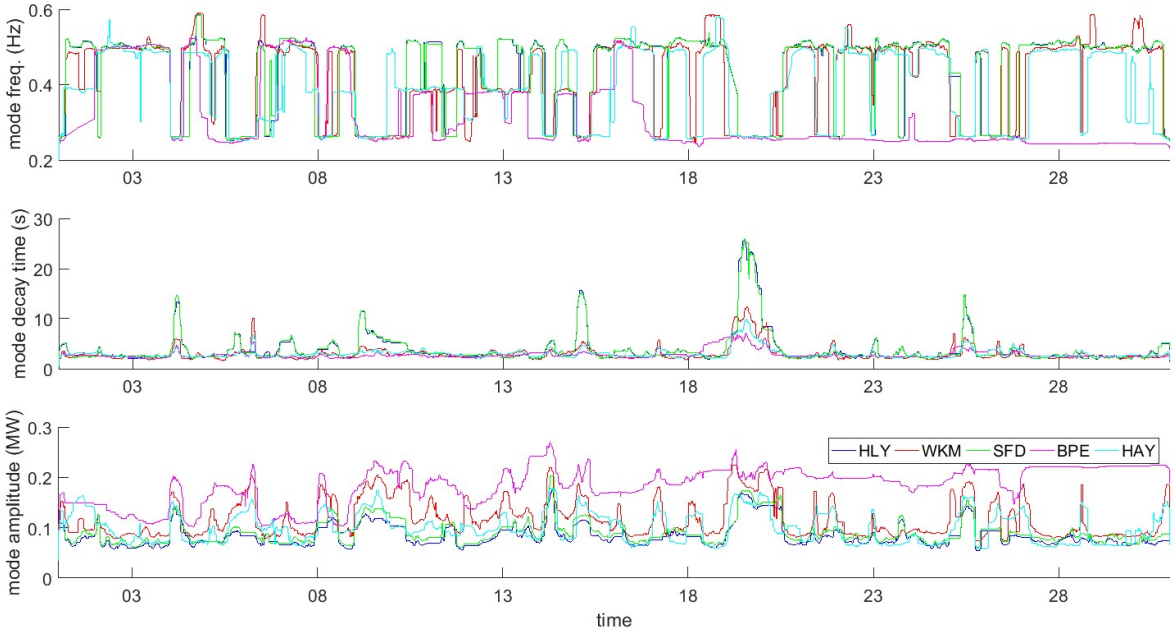

Figure 104: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency

- 0.25 Hz mode. Decay time around 3 seconds, increasing to around 20 seconds at certain periods.
- 0.5 Hz-0.6 Hz Decay time around 3 seconds.

Using active power:

- 0.25 Hz mode at most sites with a decay time between 3-25 seconds. The peak decay of around 25 seconds was observed at Stratford and Huntly around 20th of June.
- ~0.4 Hz mode at Haywards, Whakamaru and Bunnythorpe at times.
- ~0.5-0.6 Hz mode for all substations at certain periods with a decay time around 3 seconds when dominant.
- Maximum oscillation amplitude ~250 kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

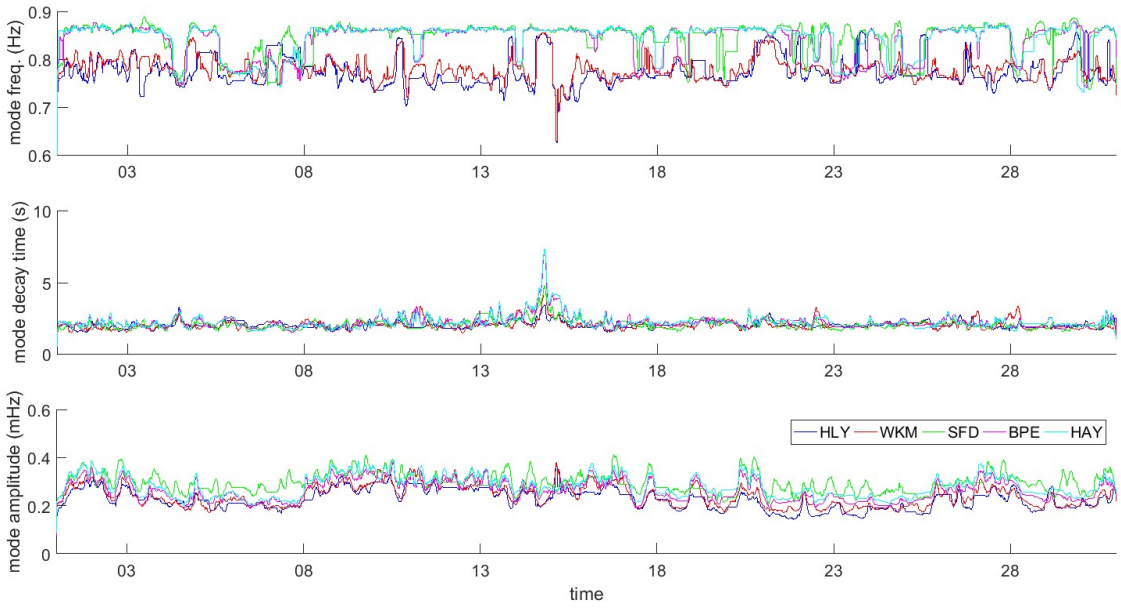

Figure 115: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

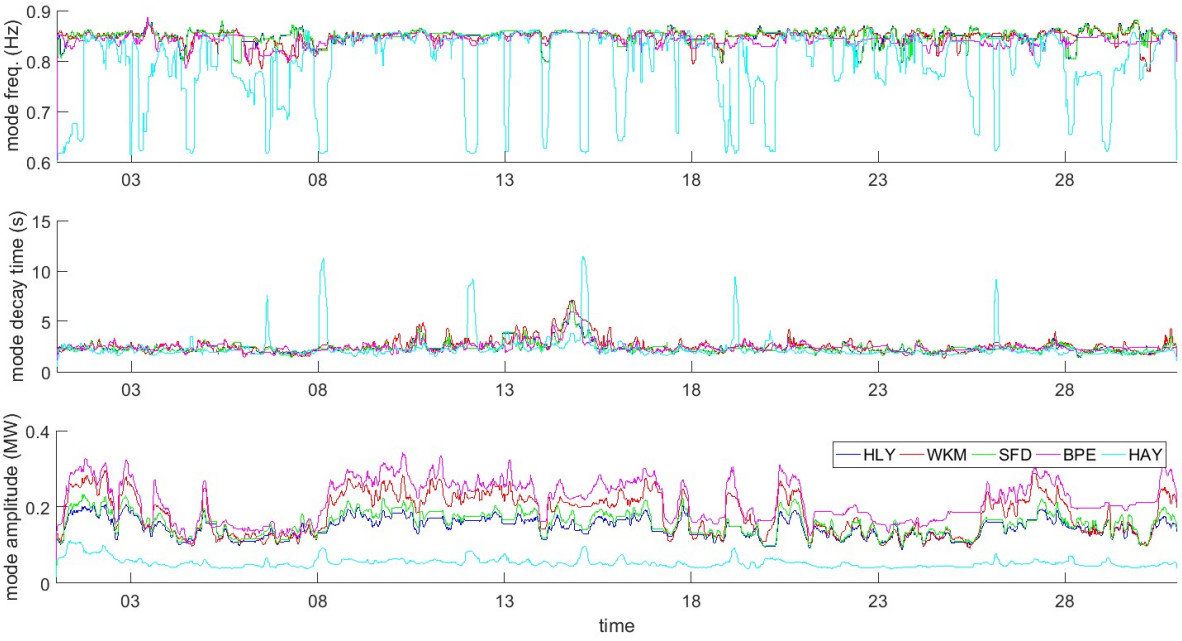

Figure 126: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Modes at ~0.8 Hz and 0.86 Hz observed.
- Decay time typically around 2 seconds at most sites occasionally peaking as high as 7 seconds.
- Maximum amplitude ~0.4 mHz.

Using active power:

- Modes at ~0.85 Hz (all substations) and 0.62 Hz (Haywards) observable.
- Decay time less than 6 seconds at most sites except Haywards where decay time ranges from 2-10 seconds throughout the month.
- Maximum amplitude at Bunnythorpe ~300 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

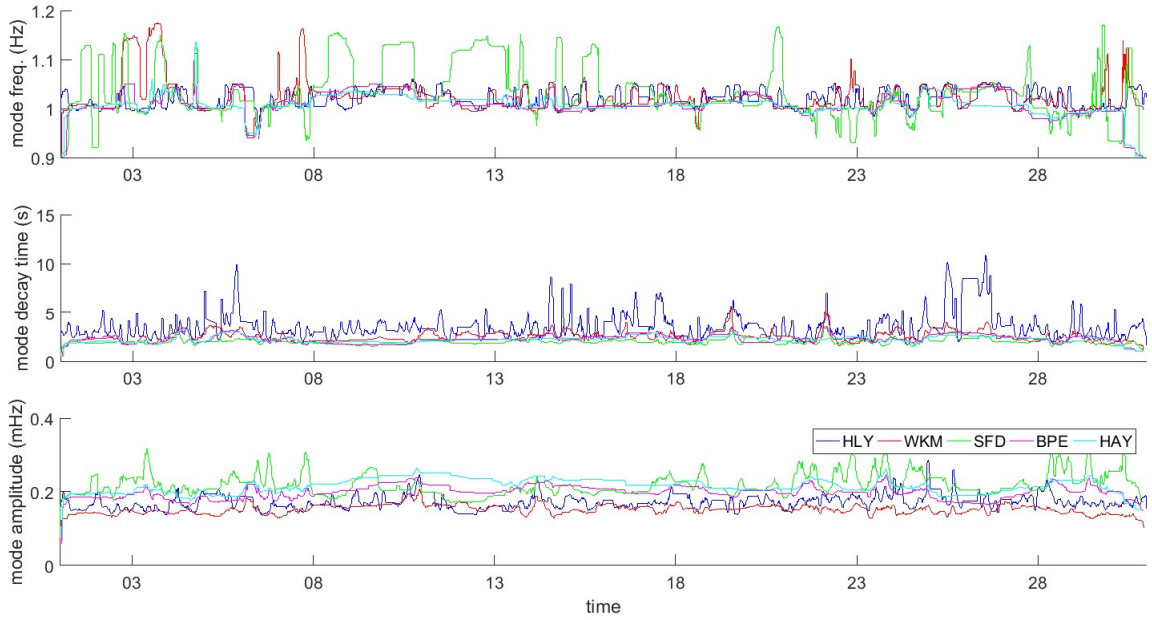

Figure 17: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

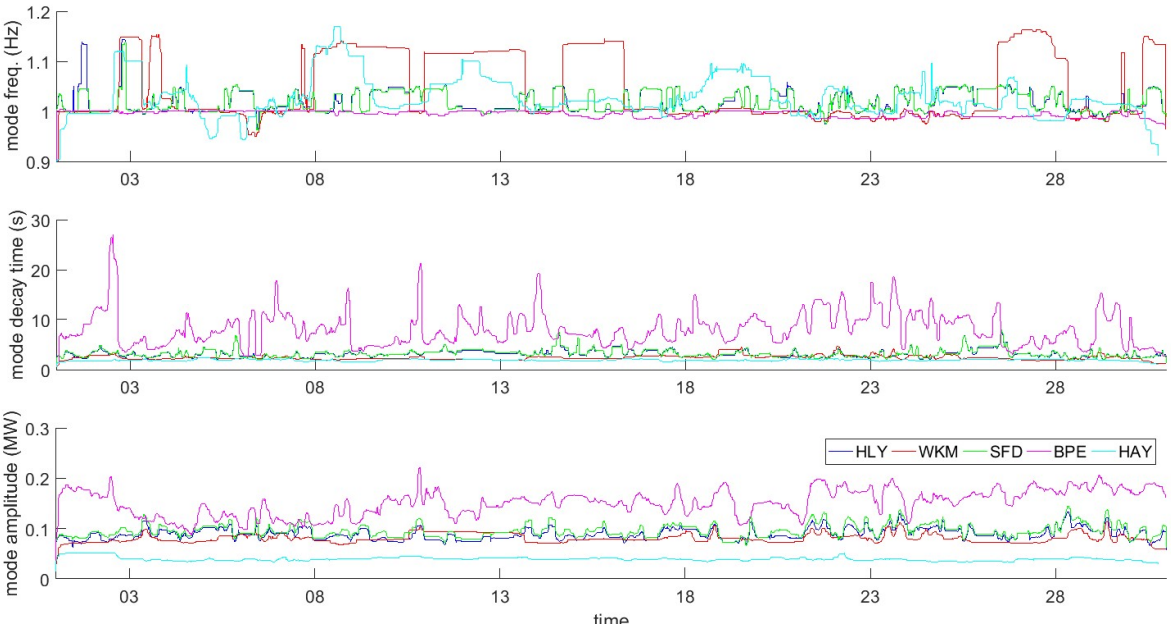

Figure 18: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at ~0.93 Hz, 1.00 Hz, 1.05 Hz, and ~1.15 Hz.
- Highest mode amplitude occurring at Stratford for various frequencies. Most decay times are under 10 seconds.
- Mode 1.05 Hz peaks around 10 seconds observed from Huntly at certain periods.

Using active power

- Most modes are typically well damped.
- Mode 1 Hz exhibits decay time around 28 seconds around the beginning of the month observed at Bunnythorpe.
- Maximum oscillation amplitude 200 kW.

3.7 Mode band 5: [1.2 - 1.8 Hz]

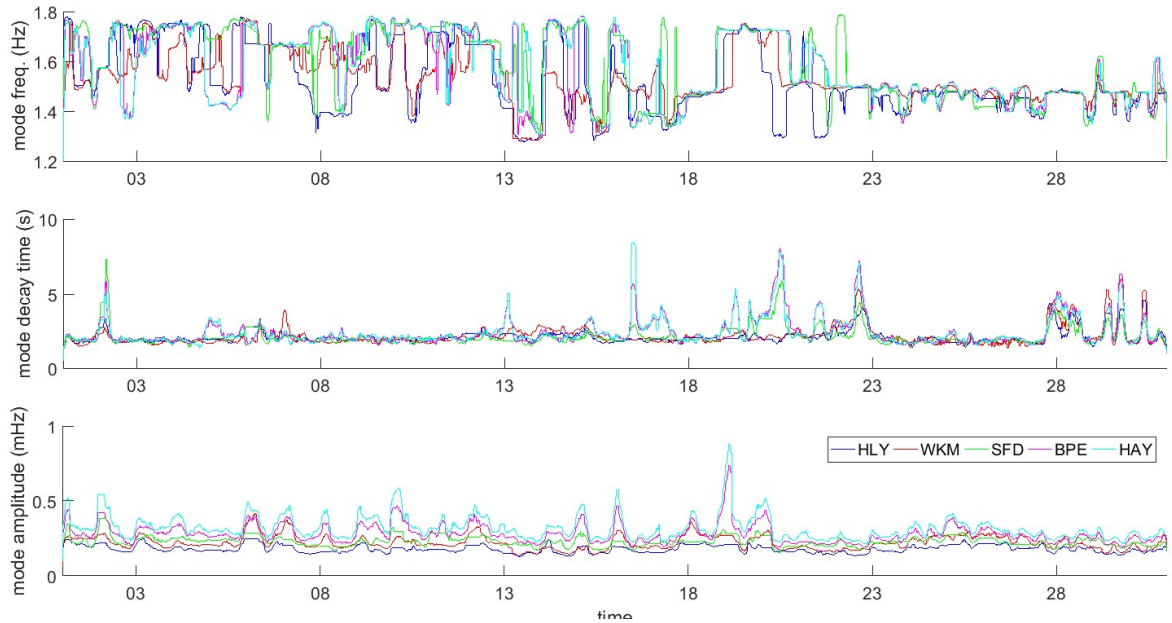

Figure 19: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

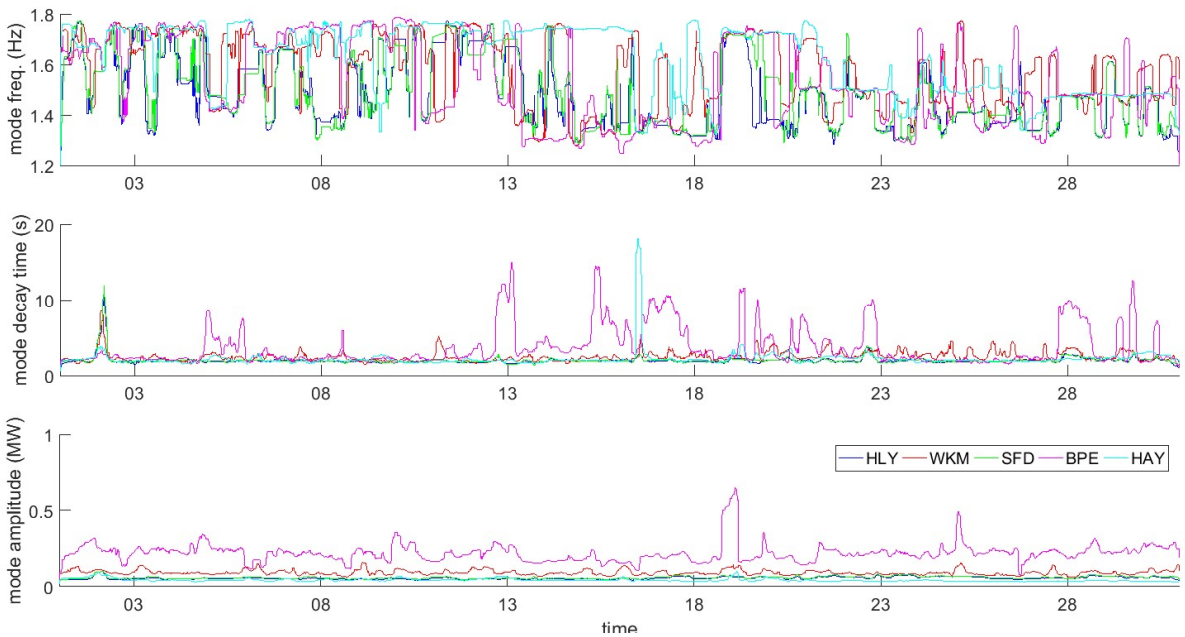

Figure 130: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at ~1.3 Hz, 1.5 Hz, 1.65, and ~1.78 Hz.
- Maximum decay time around 8 seconds for any individual mode. Most of the month the decay time is less than 5 seconds for all modes.
- Maximum amplitude ~0.9 mHz observed at Bunnythorpe and Haywards for ~1.78 Hz. Most mode amplitude was observed to be less than 0.5 mHz throughout the month.

Using active power

- Decay time less than 10 seconds at most sites except Bunnythorpe where decay time ranges from 10-15 seconds throughout the month, and Haywards which has a maximum decay time of 17 seconds.
- Maximum amplitude ~600 kW observed for ~1.78 Hz at Bunnythorpe however appeared relatively well damped.

3.8 Mode band 6: [1.8 – 2.4 Hz]

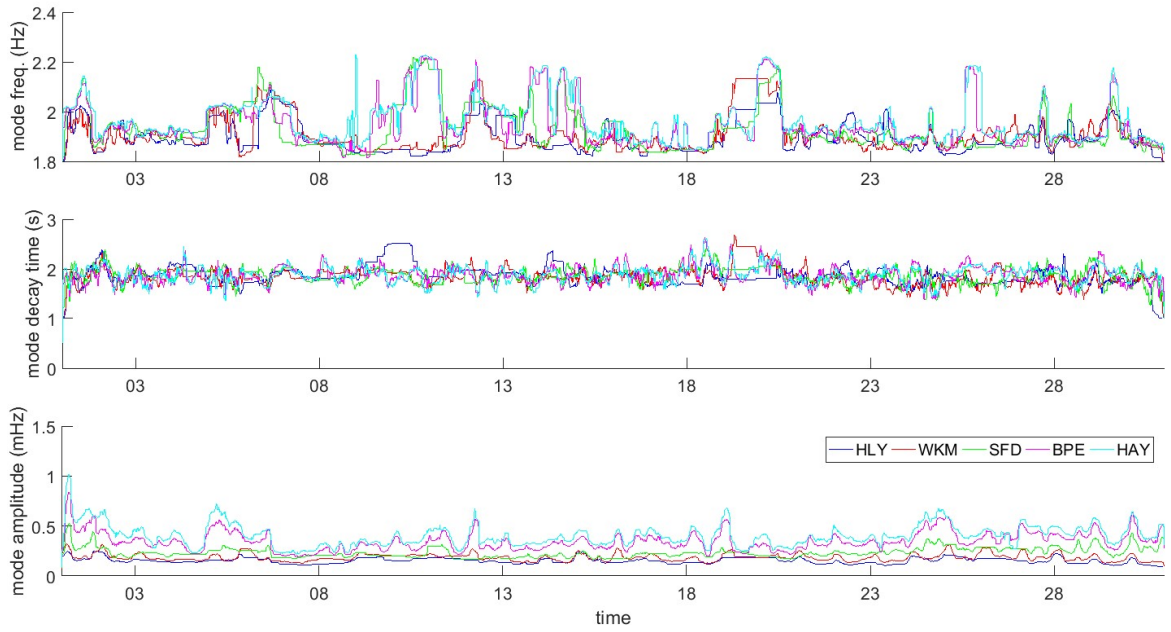

Figure 141: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

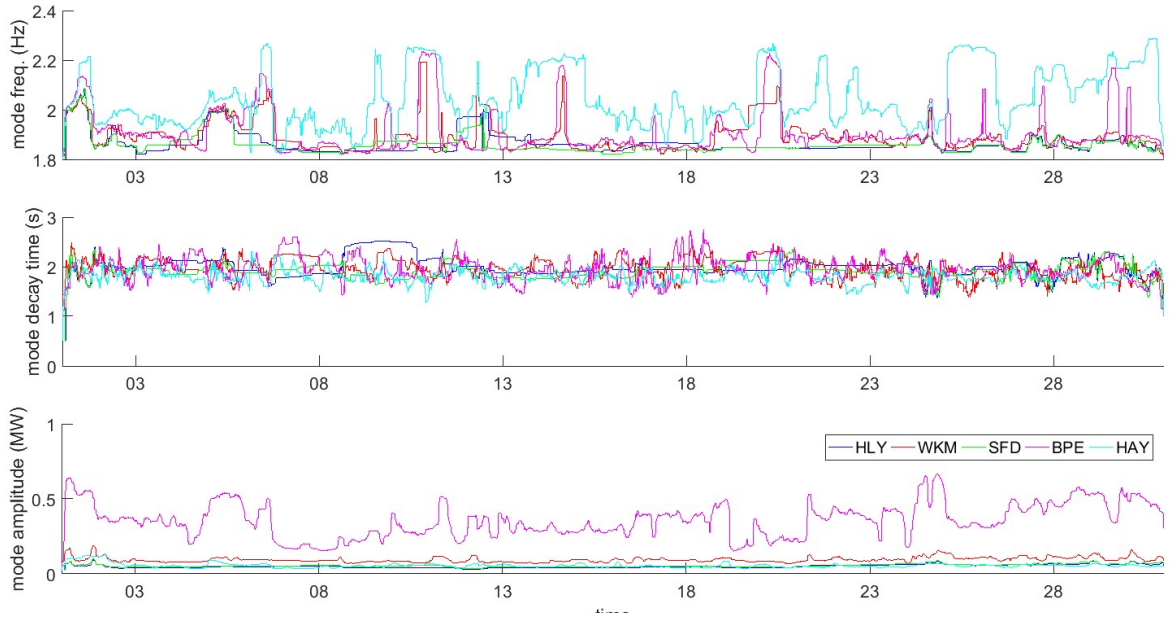

Figure 152: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes observed at ~1.9, 2, and 2.2 Hz. All modes in this band are relatively well-damped.

Using active power

- Maximum oscillation amplitude for this mode band ~600 kW, visible at Bunnythorpe.

3.9 Mode band 7: [2.4 – 4 Hz]

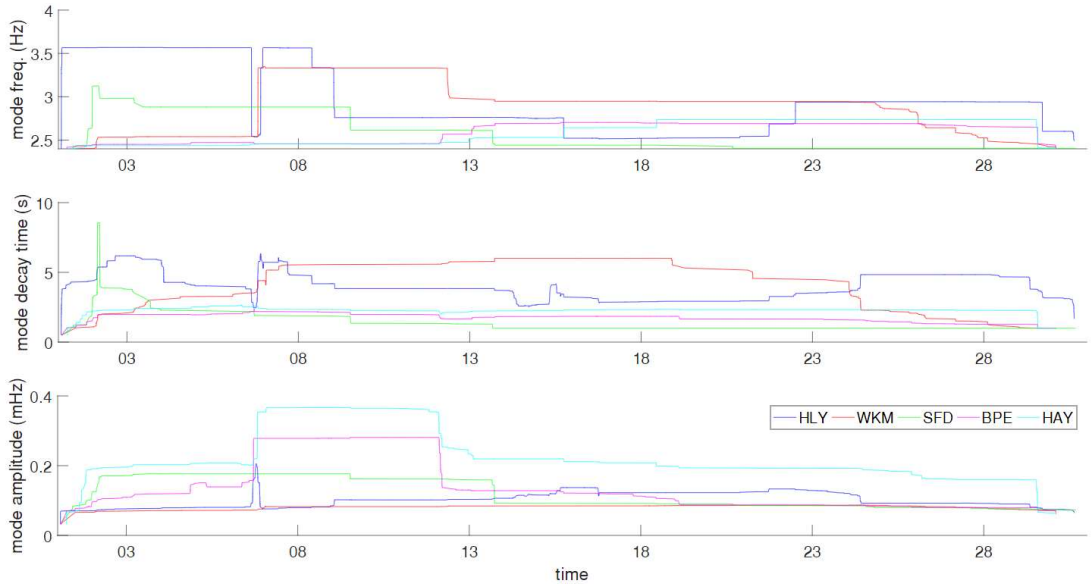

Figure 163: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

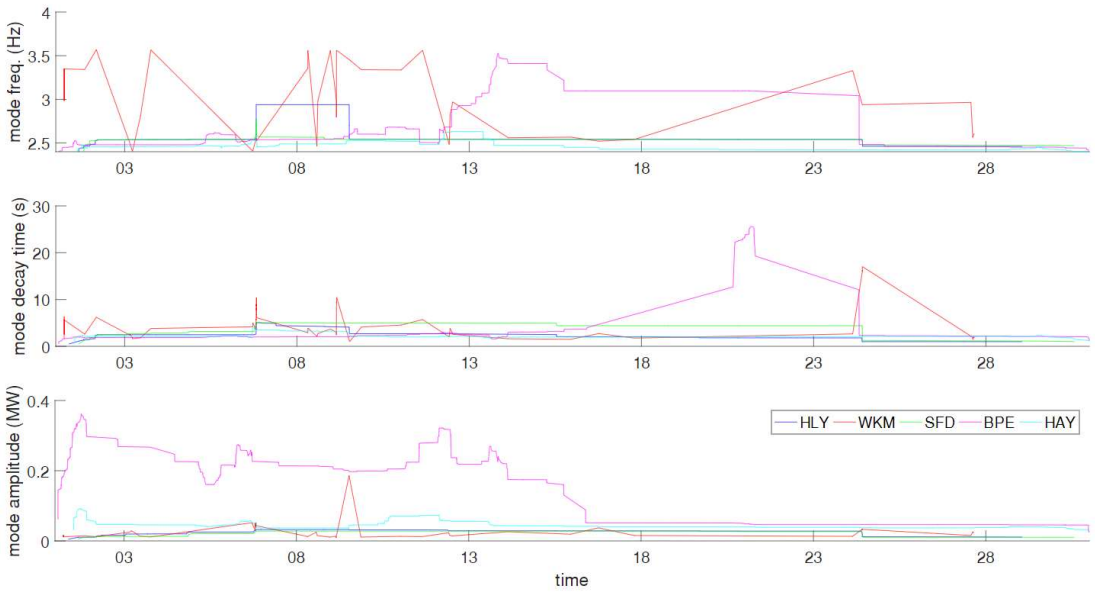

Figure 174: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Fewer data points are observed in this range. Modes observed at 2.5 Hz, 3 Hz from Stratford, and 3.5 Hz from Huntly. All modes in this band are relatively well-damped.

Using active power:

- Again fewer instances are reported. Maximum oscillation amplitude for this mode band ~380kW, visible at Bunnythorpe mostly around 2.5 Hz.

