DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – OCTOBER 2022

Transpower New Zealand Limited

October 2022

Keeping the energy flowing




TRANSPOWER

NOTICE

Version	Date	Change
1.0	12/01/2024	Final

	Position	Date
Prepared By:	Jessie Fahey, Power Systems Engineer	12/01/2024
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 October 2022. This monthly report presents these findings for October 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 October 2022
0.04 Hz	All-f	Governor modes	No significant change over the month. Well-damped
0.30 Hz	All-f Most-p	Probably control modes, and not electro-mechanical	Relatively high number of occurrences High decay time (low damping) in certain periods
0.5 – 0.6 Hz	All-f HAY-p WRK-p	Possibly Inter area modes	Decay time higher than 5s for a few periods and occasionally peaking as high as 30 seconds
0.8 - 1.0 Hz	All-f Most-p	Inter-area and Inter-station modes	Greater than 15s at times in power data Periods of high decay time
1.5-1.8 Hz	All-f Most-p	Inter-station and Local modes	High number of occurrences Periods of relatively high amplitude
~2.5 Hz	All-f All-p	Not yet identified	Low number of occurrences Reported as very poorly damped, but at low amplitude
3, 3.5 Hz	Most-f Most-p	Not yet identified	Low number of occurrences Low amplitude

This month saw the first appearance of reporting of very low damping for oscillations close to 2.5 Hz. To date, nothing has been identified as causing these low amplitude oscillations so they will simply be monitored and if these become more persistent they will be investigated further.

3 Detailed plots for October 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

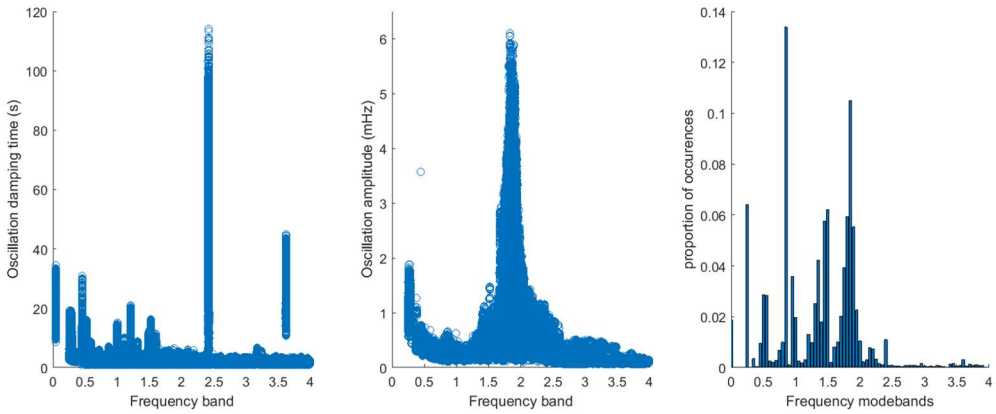

Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

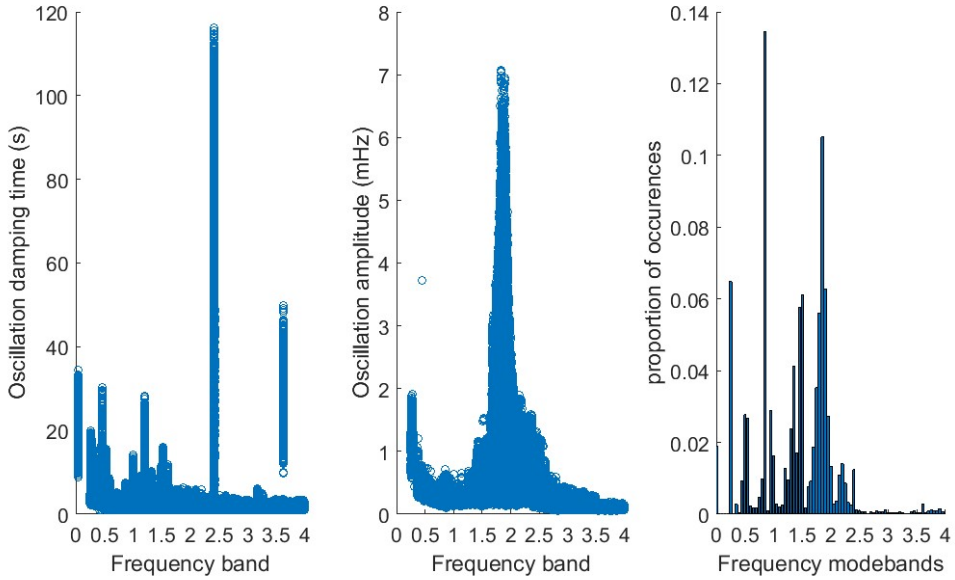

Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

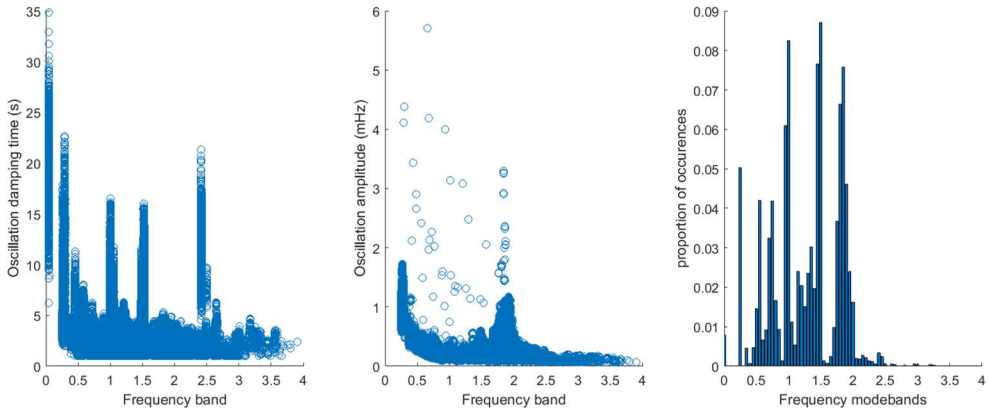

Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

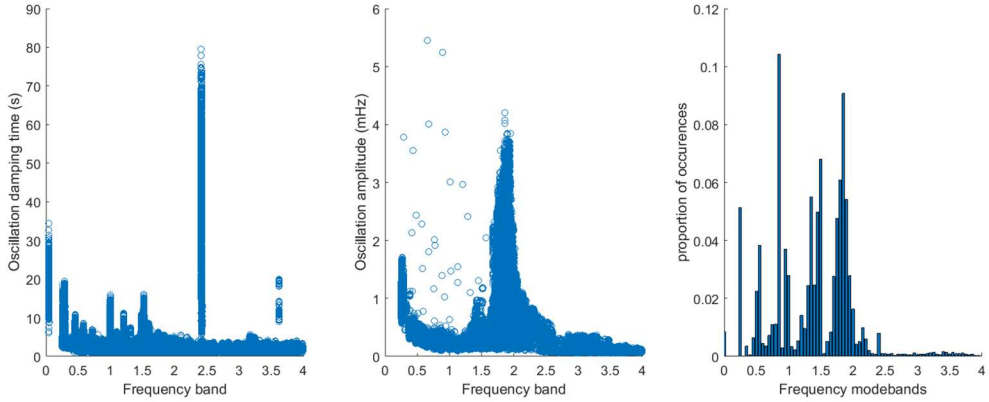

Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

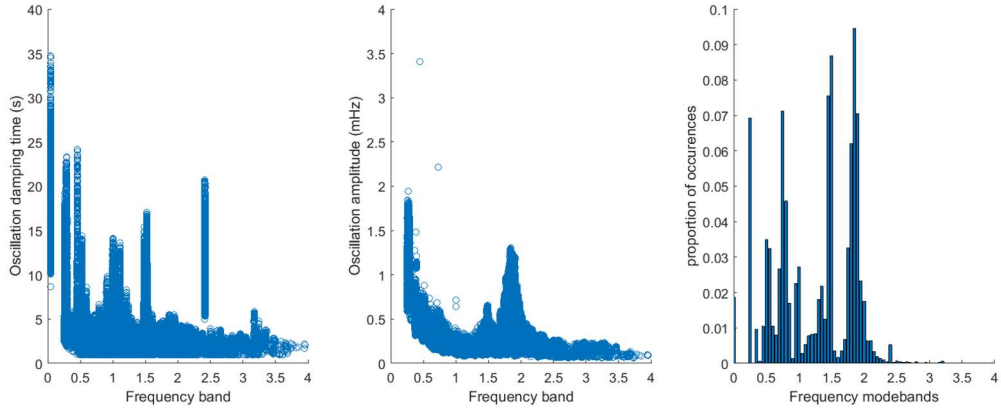

Figure 5: Wairakei mode damping, mode amplitude, and frequency histogram using frequency data

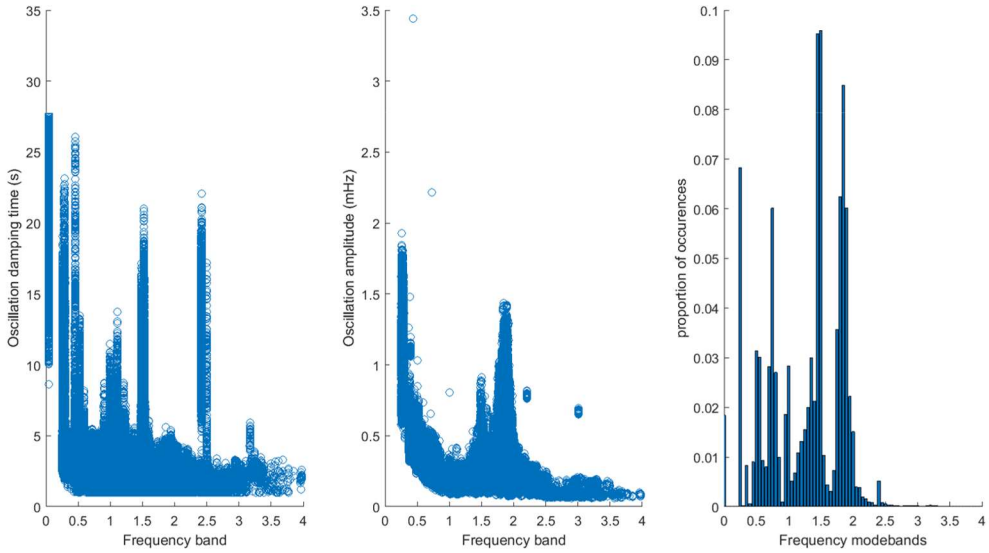

Figure 6: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

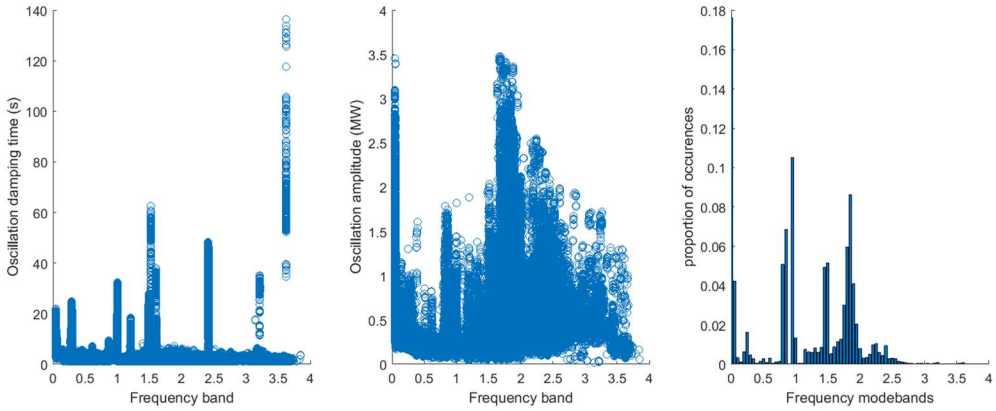

Figure 7: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

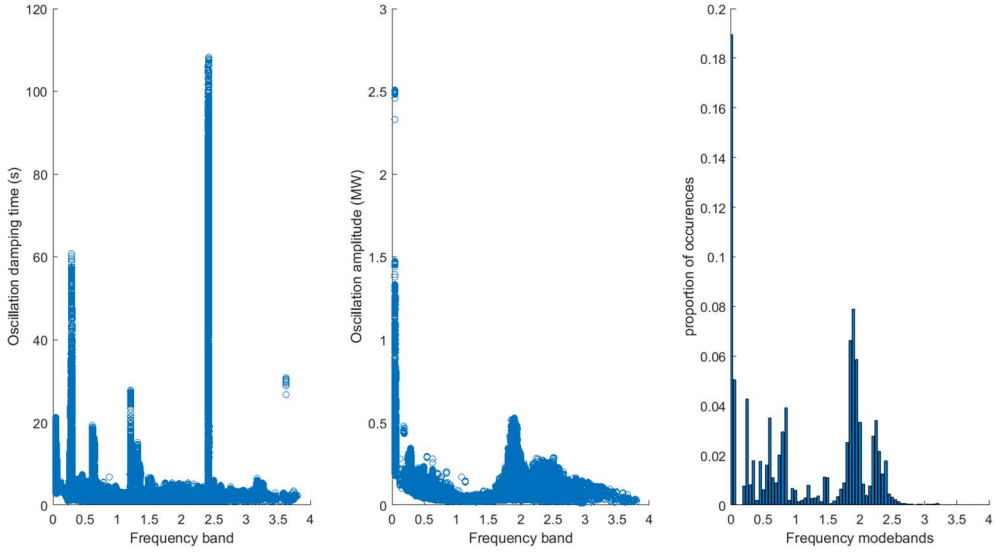

Figure 8: Haywards mode damping, mode amplitude, and frequency histogram using active power data

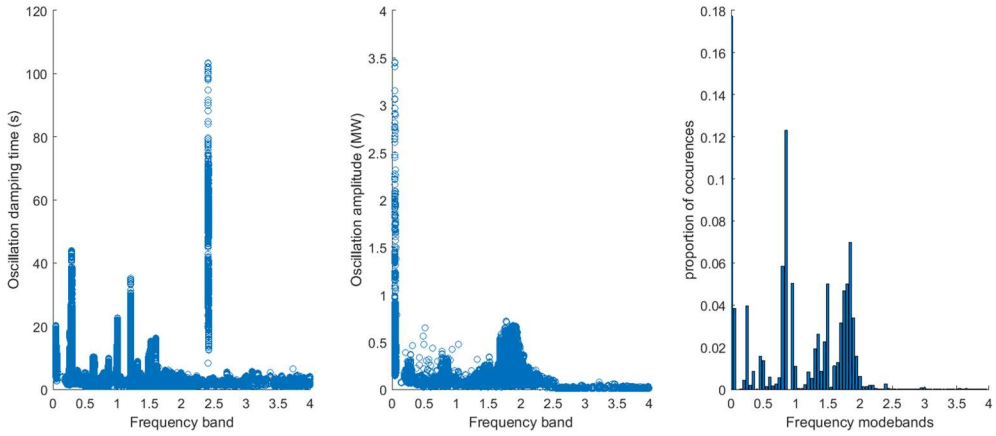

Figure 9: Huntly mode damping, mode amplitude, and frequency histogram using active power data

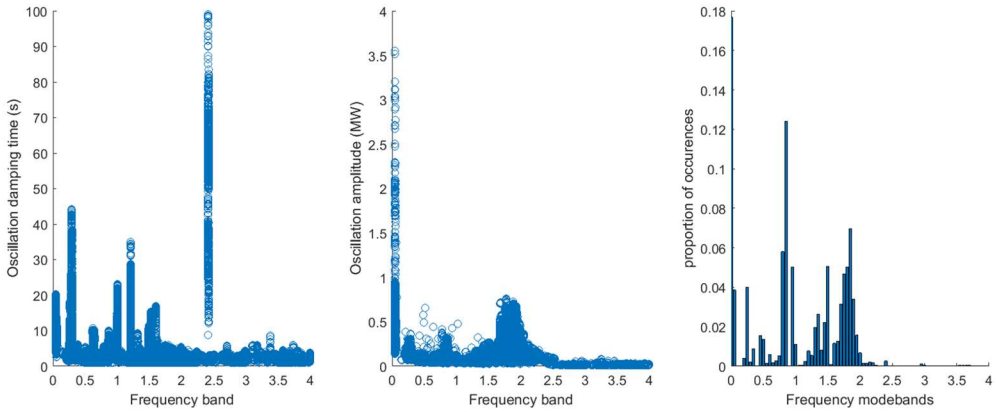

Figure 10: Stratford mode damping, mode amplitude, and frequency histogram using active power data

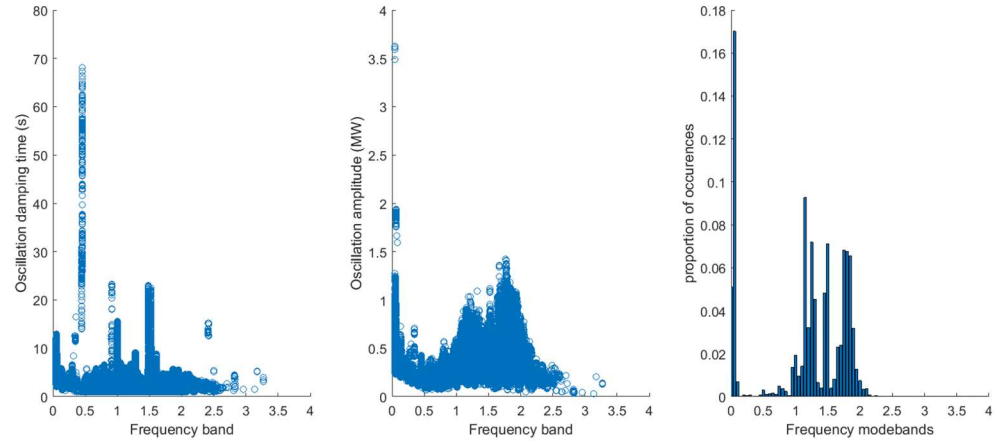

Figure 11: Wairakei mode damping, mode amplitude, and frequency histogram using active power data

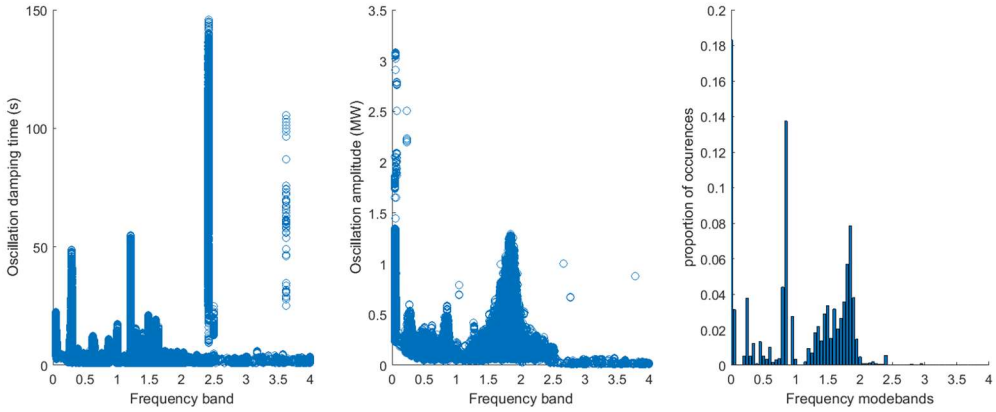

Figure 12: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

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 1.9 Hz can be observed in the October data from its number of occurrences. However the more striking information is periods of low damping reported at approximately 2.5 Hz across many sites.

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

1.9 Hz

~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

3.3 Mode band 1: [0.0 – 0.2 Hz]

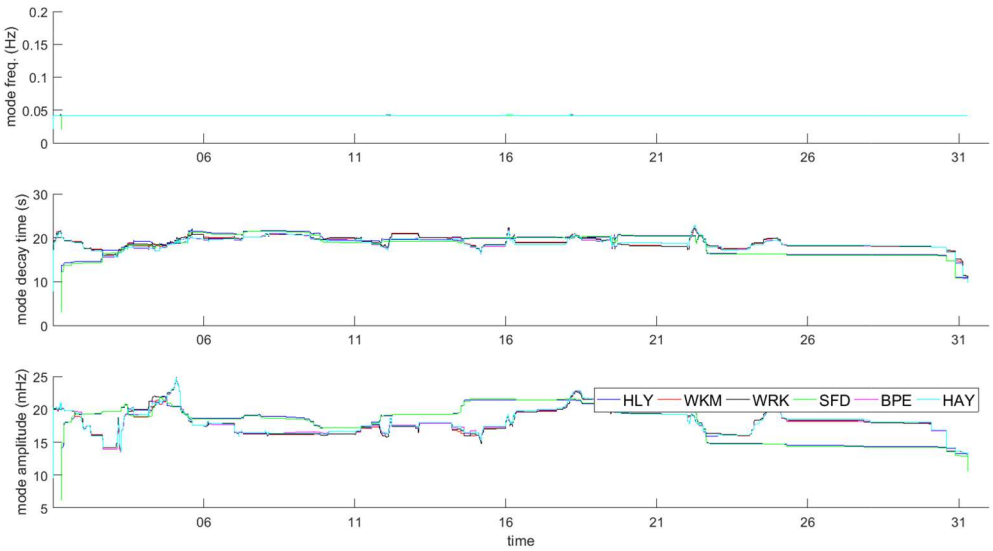

Figure 13: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

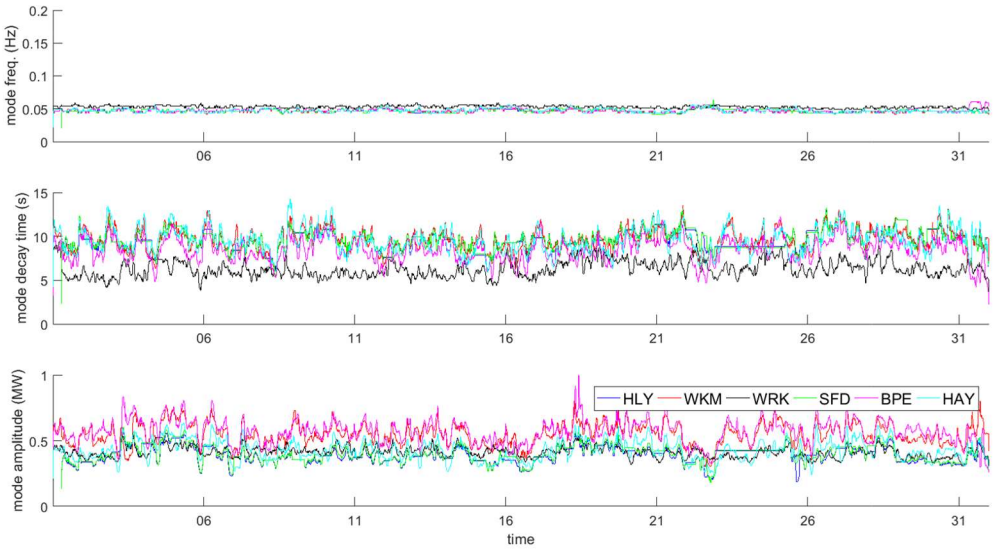

Figure 14: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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.
- Maximum oscillation amplitude ~950kW.

3.4 Mode band 2: [0.2 – 0.6 Hz]

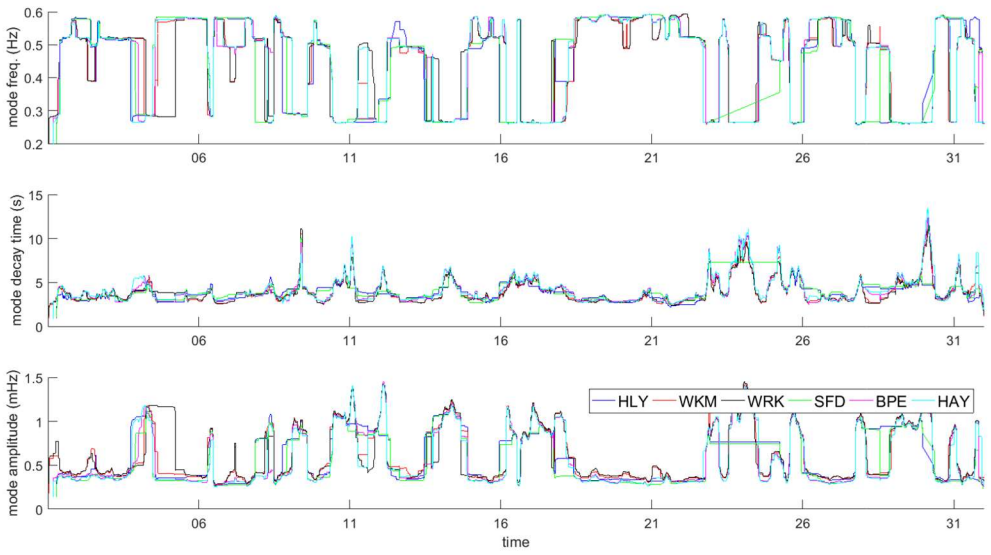

Figure 15: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

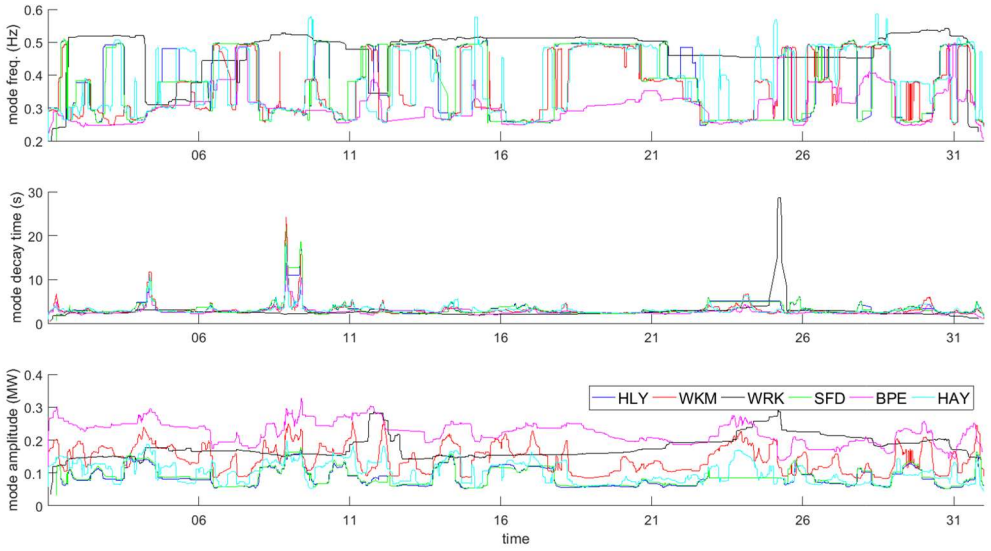

Figure 16: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency

- 0.3 Hz mode. Decay time around 3-5 seconds, increasing to 5-15 seconds at times throughout the month.
- 0.5 Hz- 0.6 Hz. Decay time around 5-10 seconds throughout the month.

Using active power:

- 0.3-0.5 Hz modes at most sites, ~0.6 Hz mode at Haywards at times.

- Decay time between 3-10 seconds, increasing to 20 seconds at certain period. A peak decay of ~30 seconds observed at Wairakei around 25th of October.
- Maximum oscillation amplitude ~300kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

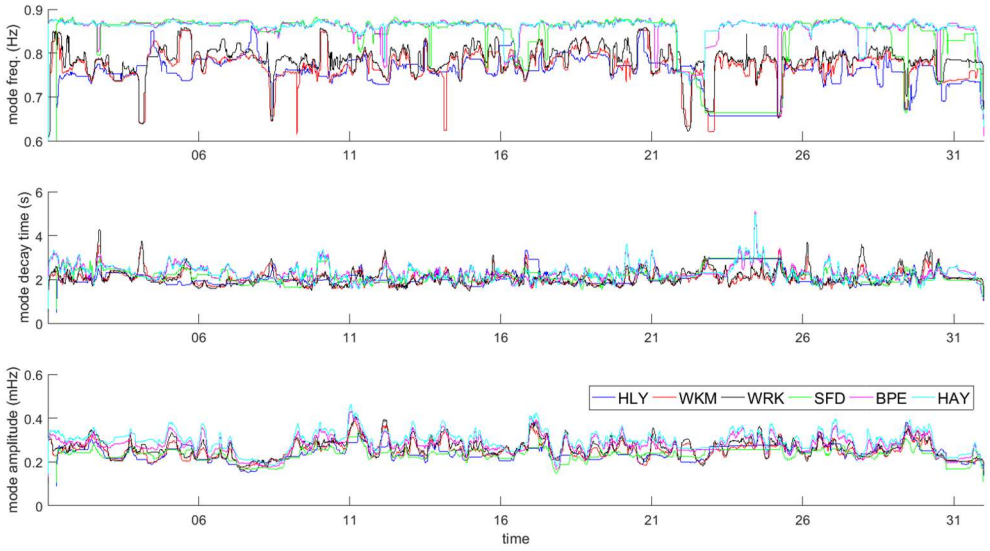

Figure 17: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

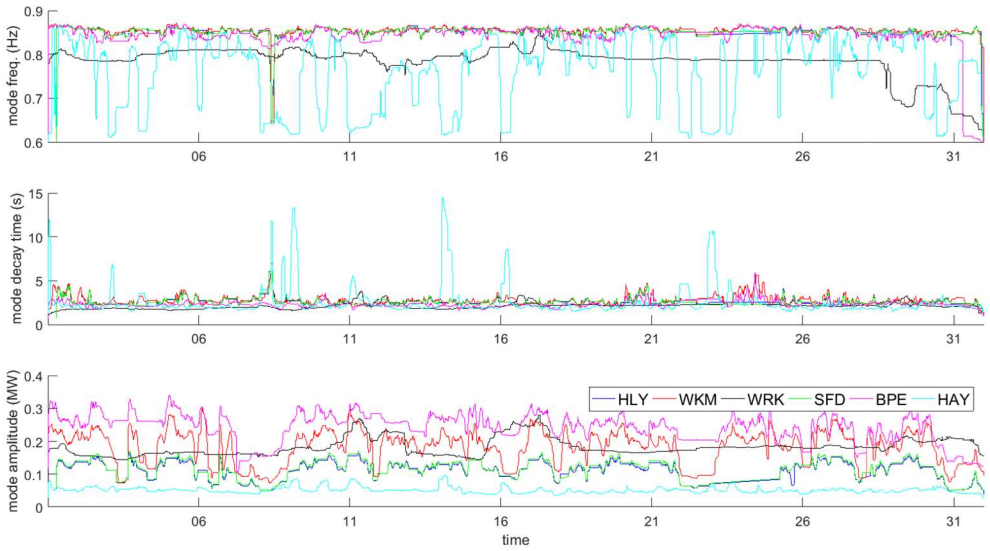

Figure 18: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Modes ~0.6 Hz, ~0.8Hz, and 0.87 Hz observed.
- Decay time typically less than 4 seconds at most sites occasionally peaking as high as 5 seconds.

- Maximum amplitude ~0.4 mHz.

Using active power

- Distinct modes 0.6 Hz, 0.8 Hz, and 0.87 Hz observed.
- Decay time less than 5 seconds at most sites except Haywards where decay time ranges from 2-13 seconds throughout the month
- Maximum amplitude at Bunnythorpe ~300 kW

3.6 Mode band 4: [0.9 – 1.2 Hz]

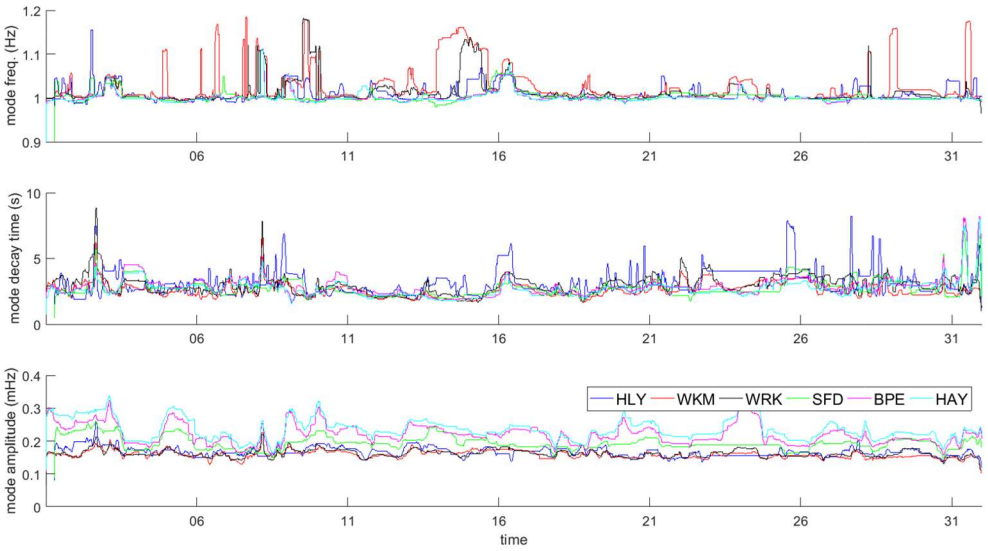

Figure 19: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

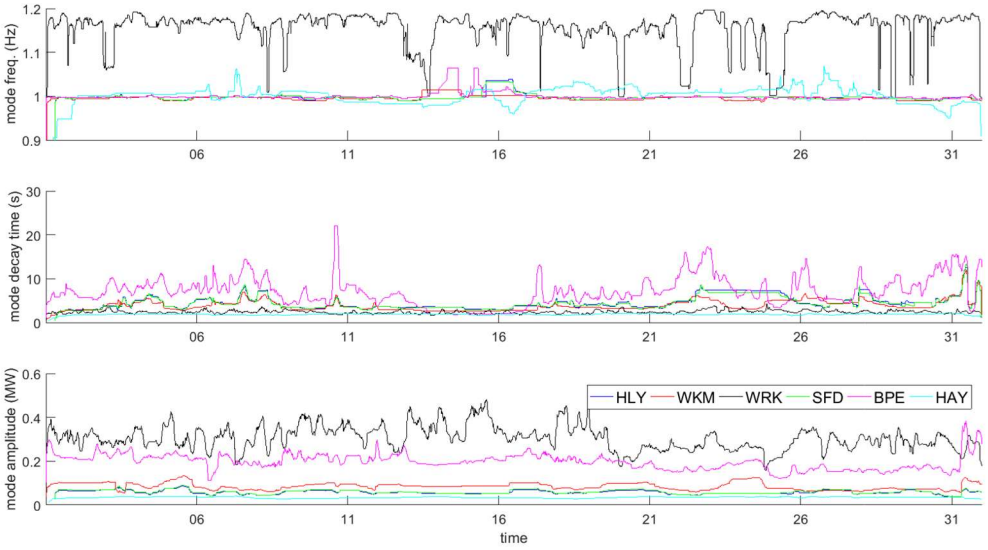

Figure 20: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at 1.00 Hz, 1.05 Hz,1.1 Hz and 1.18 Hz.
- Most modes decay time are under 5 seconds. Mode 1.05 Hz peaks around 8 seconds observed from Huntly at certain periods.

Using active power

- Most modes are typically well damped except for Bunnythorpe modes which exhibited a relatively high decay time around 10 seconds increasing to 20 seconds at certain periods.
- Maximum oscillation amplitude is ~400kW.

3.7 Mode band 5: [1.2 - 1.8 Hz]

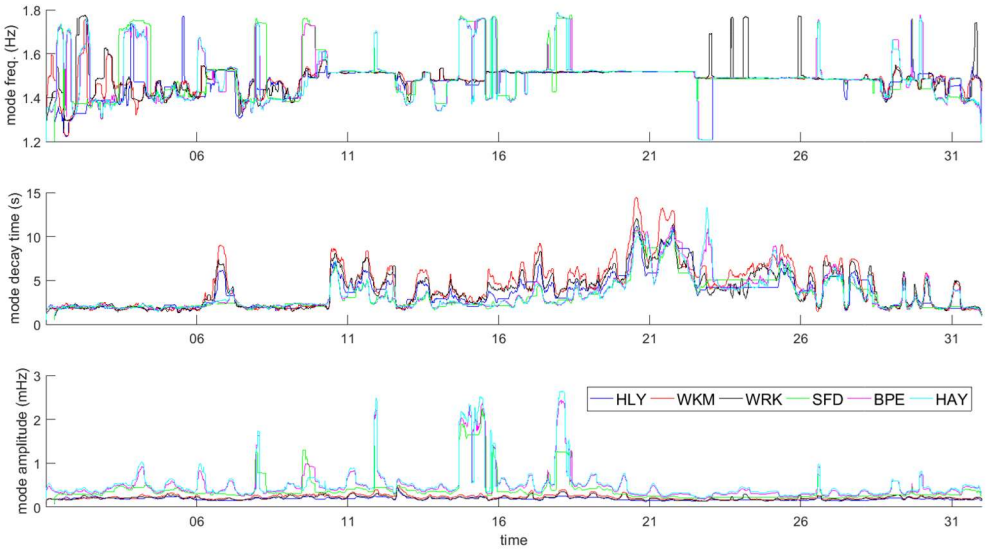

Figure 21: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

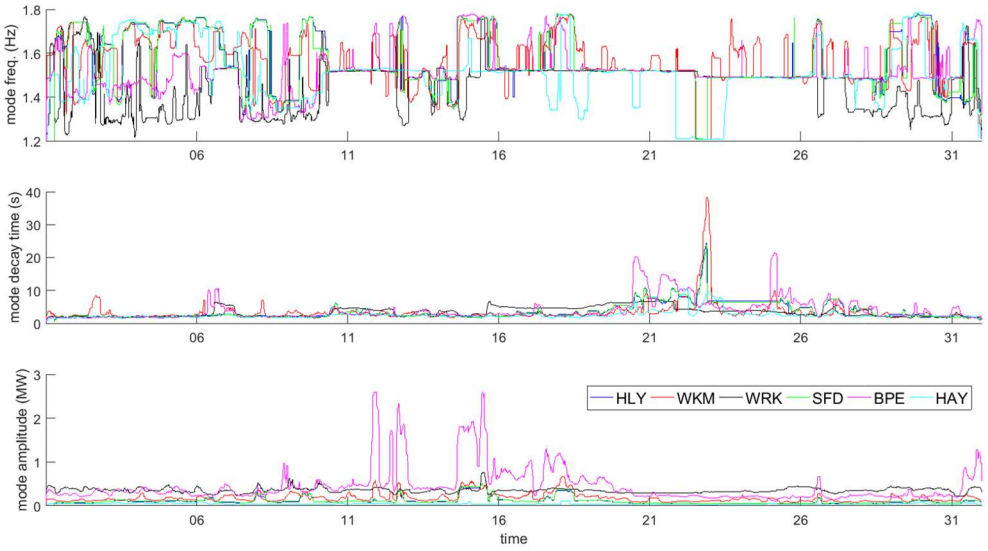

Figure 22: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes around 1.3 Hz - 1.5 Hz, and ~1.8 Hz.
- Maximum decay time 14 seconds for any individual mode. Most of the month the decay time is less than 10 seconds for all modes.
- Maximum amplitude ~2.5 mHz observed at Bunnythorpe and 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 mode 1.6 Hz where the peak decay time observed ~40 seconds at Whakamaru on 23rd of October.
- Maximum amplitude ~2.5 MW observed at Bunnythorpe mid-month but was relatively well damped.

3.8 Mode band 6: [1.8 – 2.4 Hz]

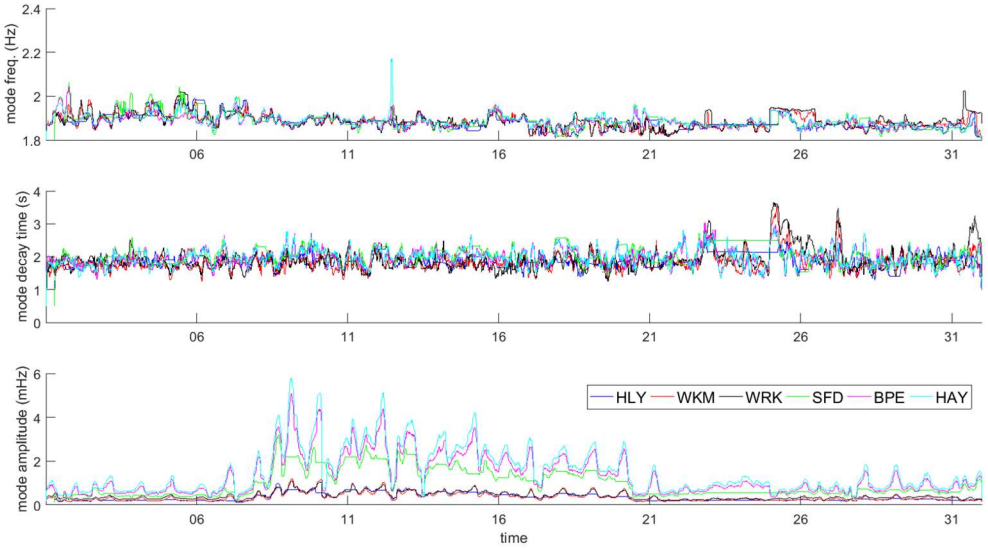

Figure 23: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

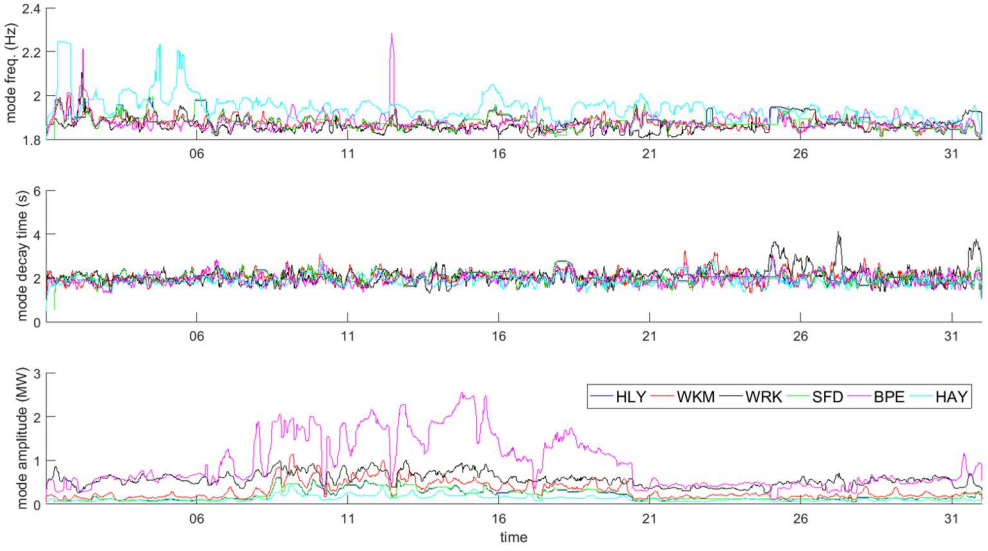

Figure 24: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes at 1.9 Hz, 2 Hz, and 2.2 Hz observed.
- Mode 1.9 Hz decay time peaked at around 3.5 seconds later in the month.

- Maximum amplitude of 5 mHz observed for 1.9 Hz mode at Bunnythorpe and Haywards.

Using active power

- All modes in this band are relatively well-damped.
- Maximum oscillation amplitude for this mode band ~2.5 MW particularly visible at Bunnythorpe (1.9 Hz) around the middle of the month.

3.9 Mode band 7: [2.4 – 4 Hz]

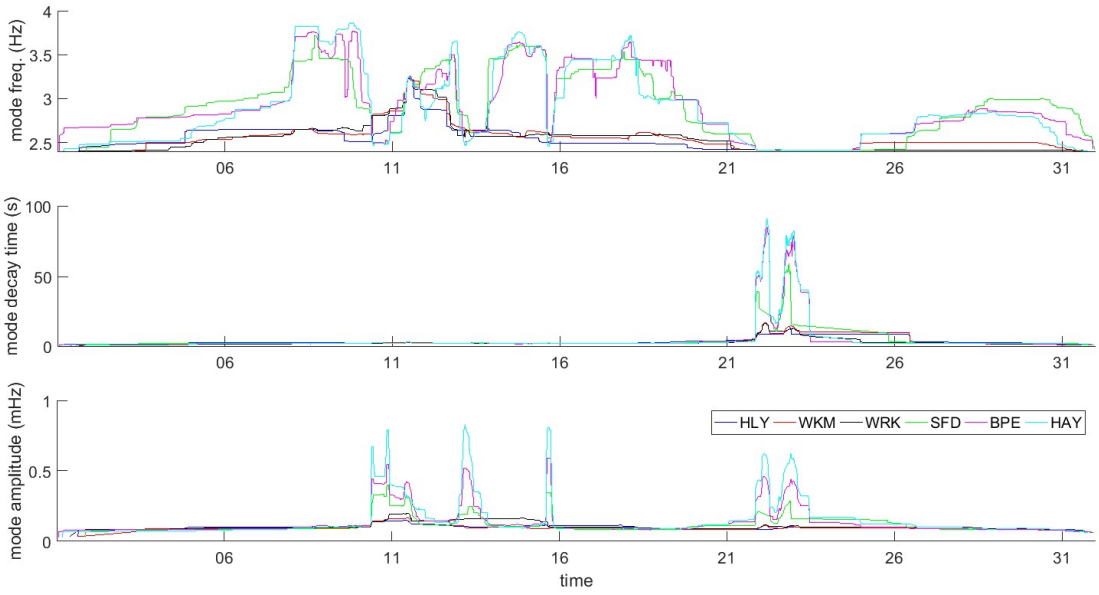

Figure 25: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

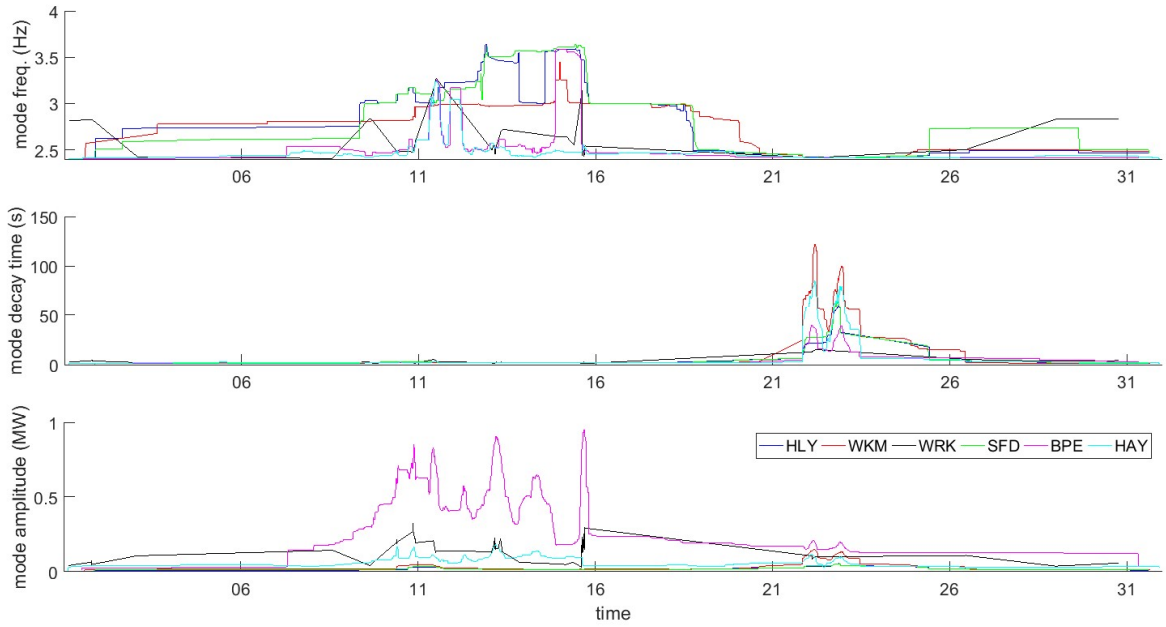

Figure 26: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Modes observed at 2.4-2.5 Hz, ~3 Hz and ~3.5 Hz at most sites.
- Most modes in this band are relatively well-damped. However, the 2.4 Hz mode has an 80 second damping time near the 22nd of October, observed at most sites.

Using active power:

- A 120 second damping time was observed for the 2.4 Hz mode again around 22nd of October as in the frequency data. This was at low amplitude.
- Maximum oscillation amplitude for this mode band 1MW, visible at Bunnythorpe (for well damped modes).

