

DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – DECEMBER 2022

Transpower New Zealand Limited

December 2022

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 December 2022. This monthly report presents these findings for December 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 December 2022
0.04 Hz	All-f	Governor modes	Well-damped. No significant change over the month
0.27 Hz	All-f Most-p	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
0.8-1.0 Hz	All-f All-p	Inter-area and Inter-station modes	Greater than 20s at times in power data Periods of high decay time
1.7-1.9 Hz	All-f All-p	Inter-station and Local modes	High number of occurrences Periods of relatively high amplitude
2.5, 3, 3.25 Hz	Most-f	Not yet identified	Low number of occurrences Well damped

Unfortunately the Wairakei (WRK) PMU was again affected by works on site and data from it is not available from December 2022 through to October 2023.

The occasional poorly damped 2.5 Hz oscillations reported in October are again absent this month.

3 Detailed plots for December 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

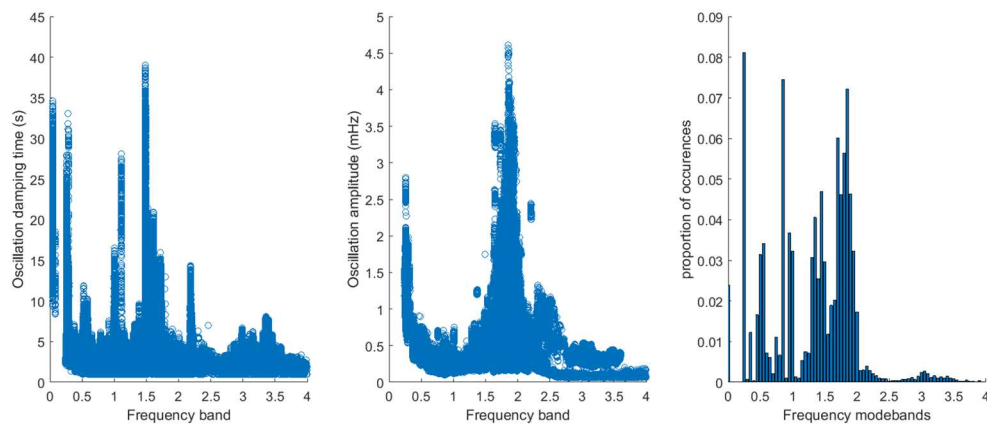


Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

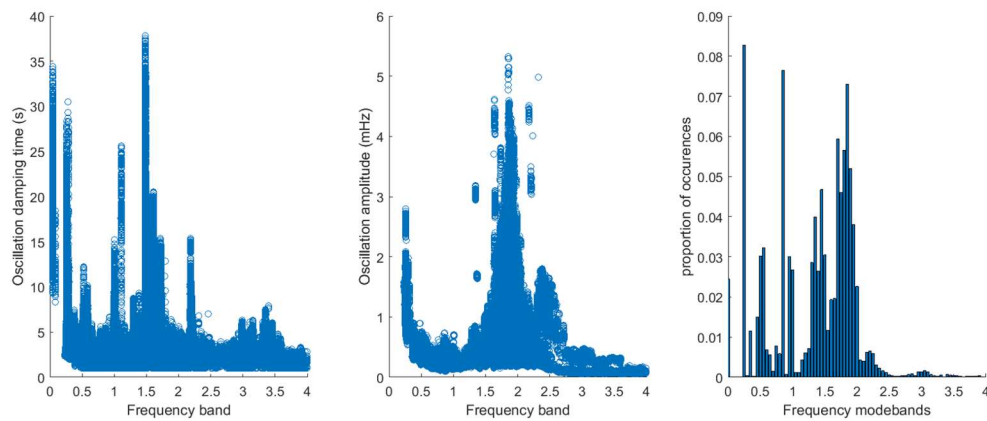


Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

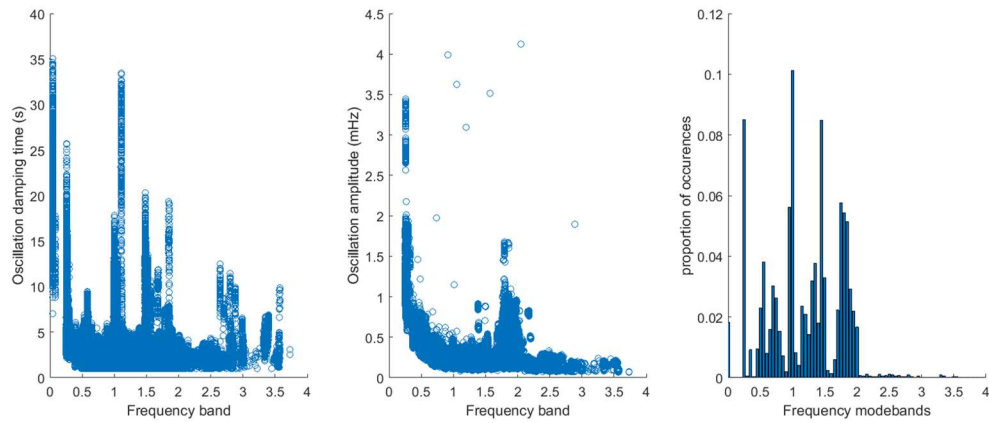


Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

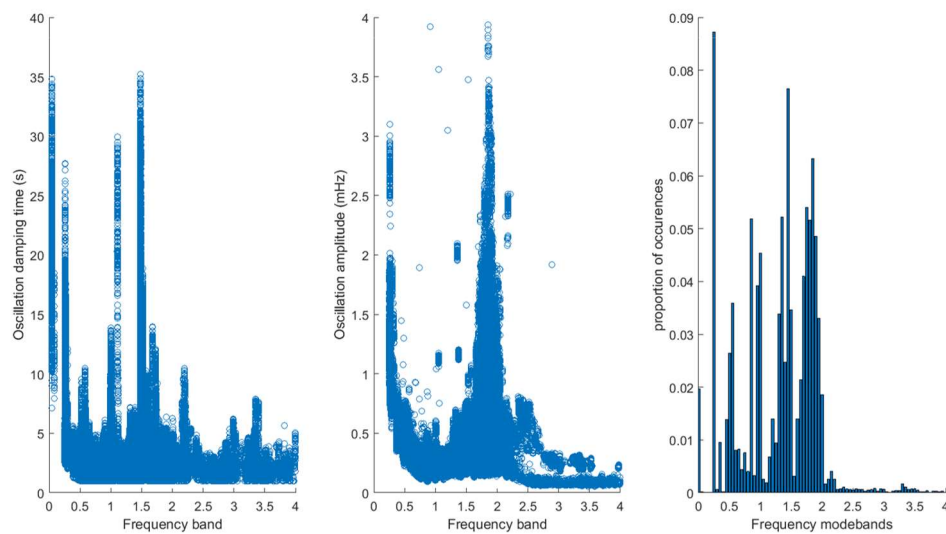


Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

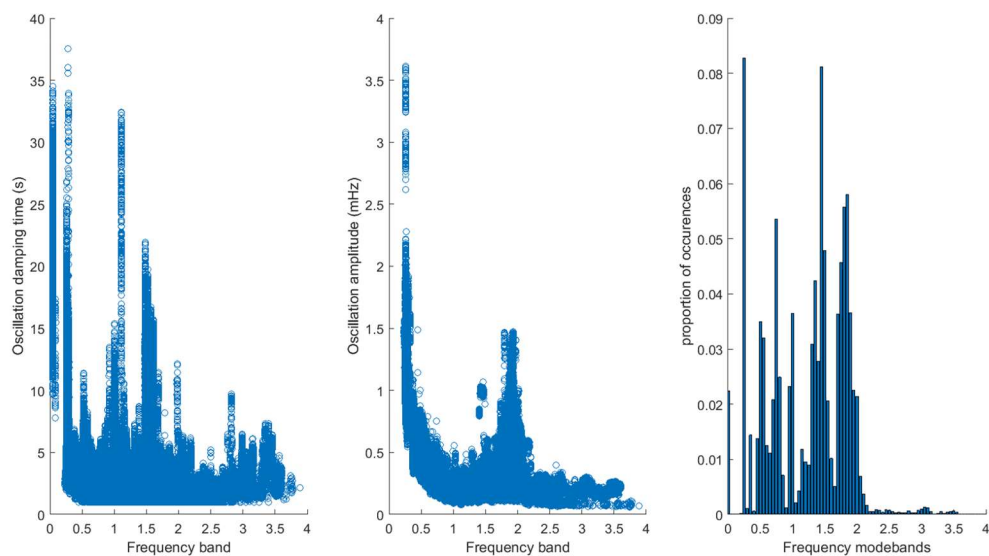


Figure 5: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

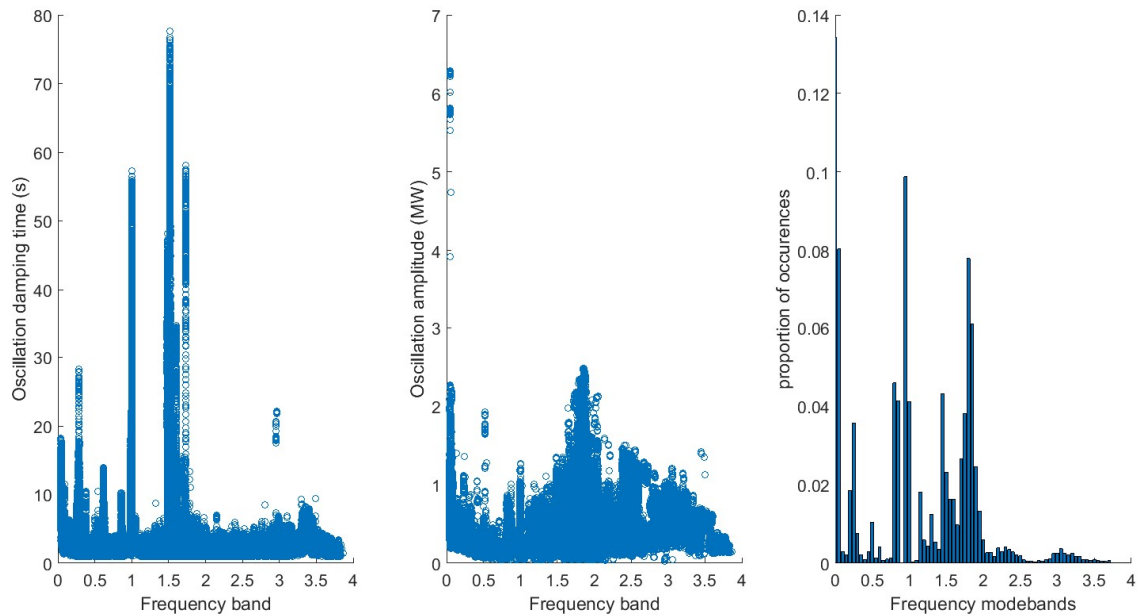


Figure 6: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

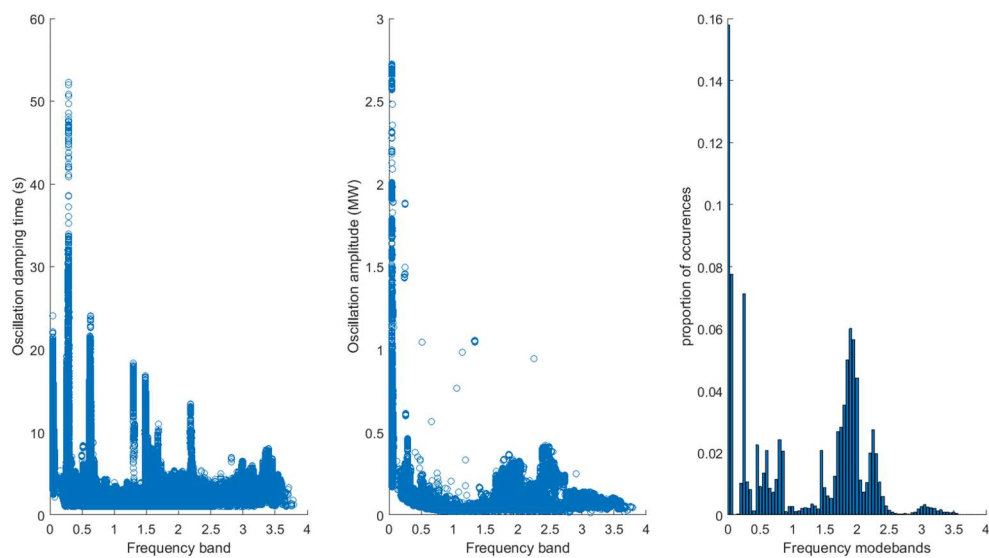


Figure 7: Haywards mode damping, mode amplitude, and frequency histogram using active power data

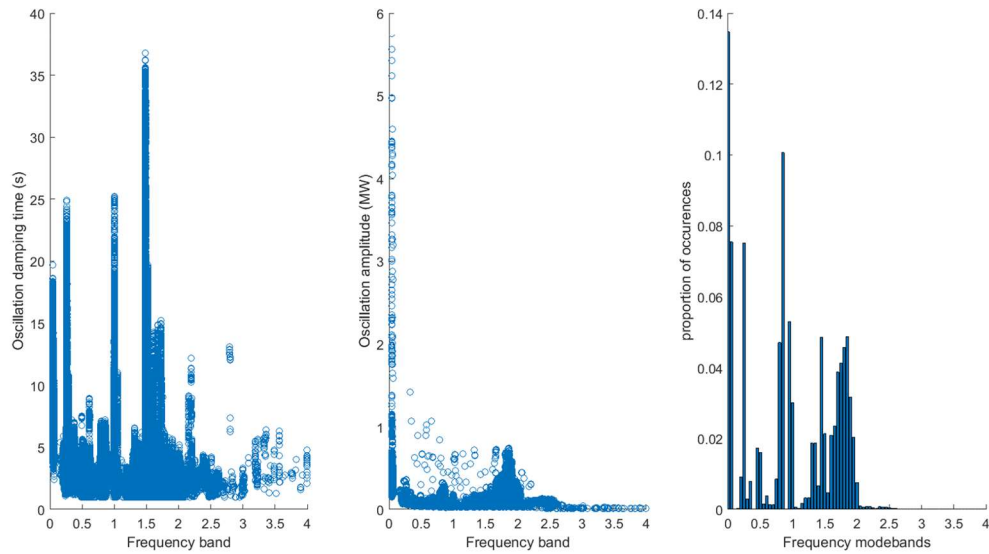


Figure 8: Huntly mode damping, mode amplitude, and frequency histogram using active power data

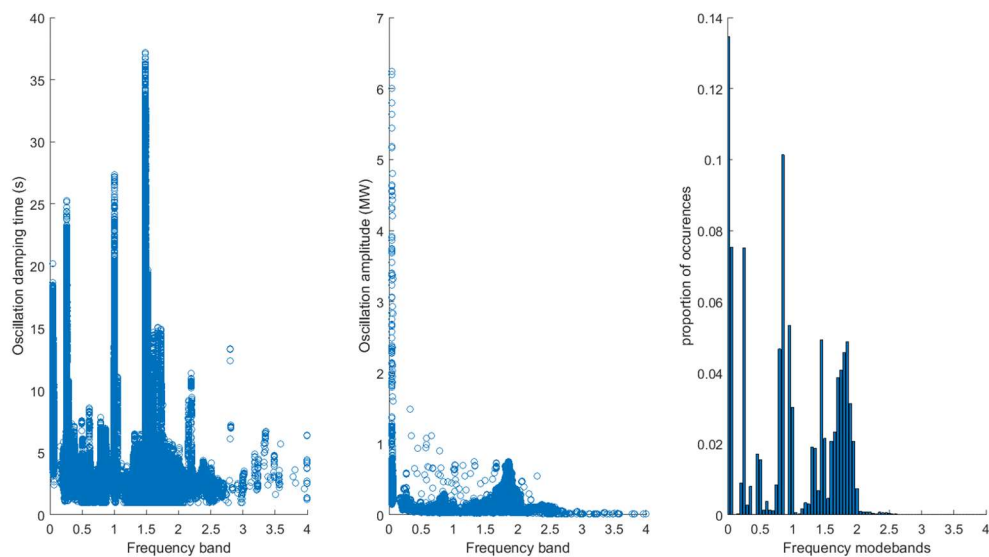


Figure 9: Stratford mode damping, mode amplitude, and frequency histogram using active power data

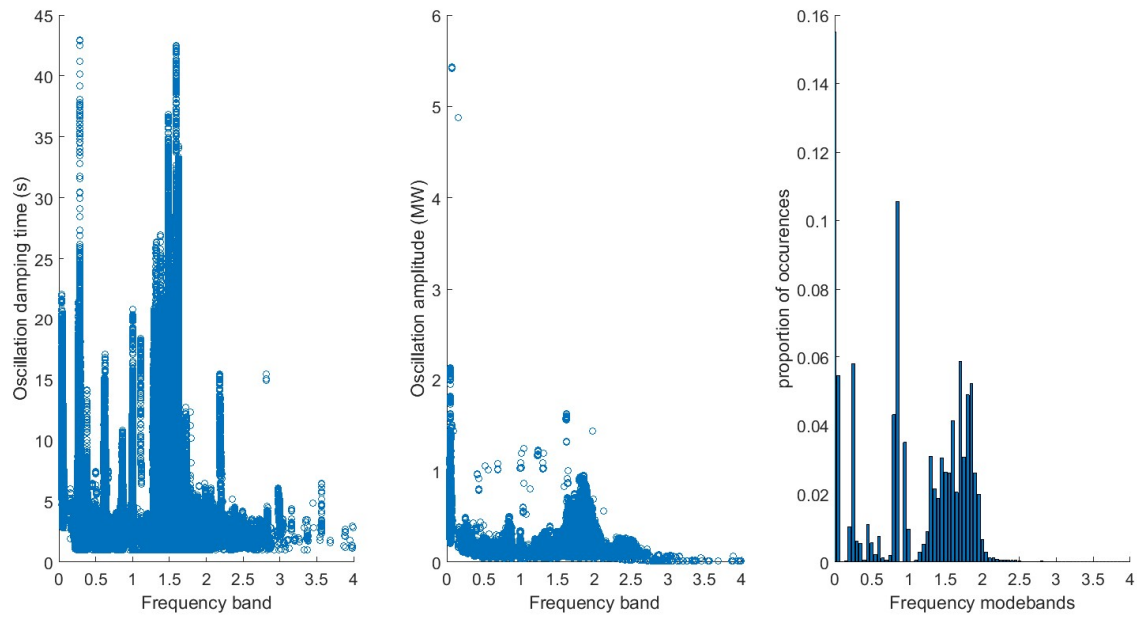


Figure 10: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

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 December 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
- 2.2 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]

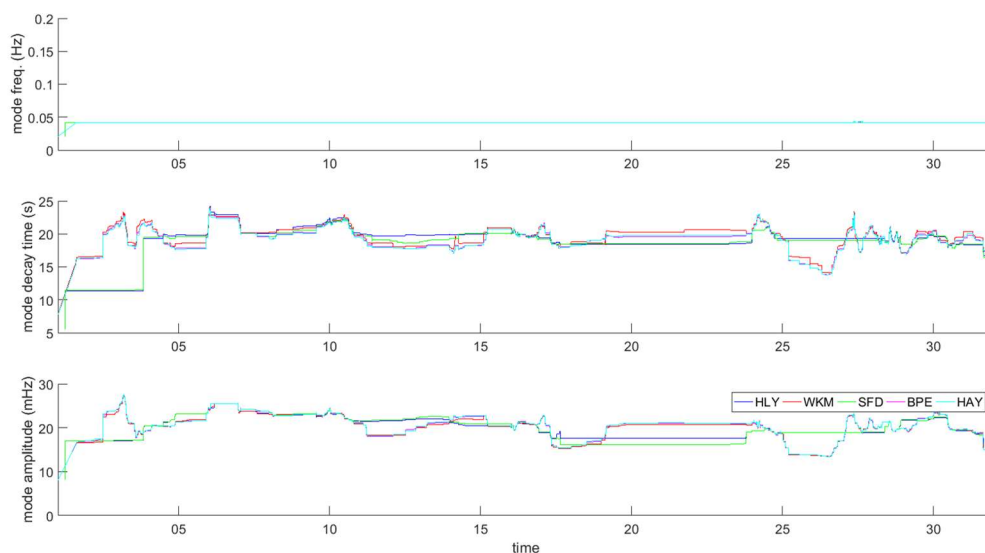


Figure 11: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

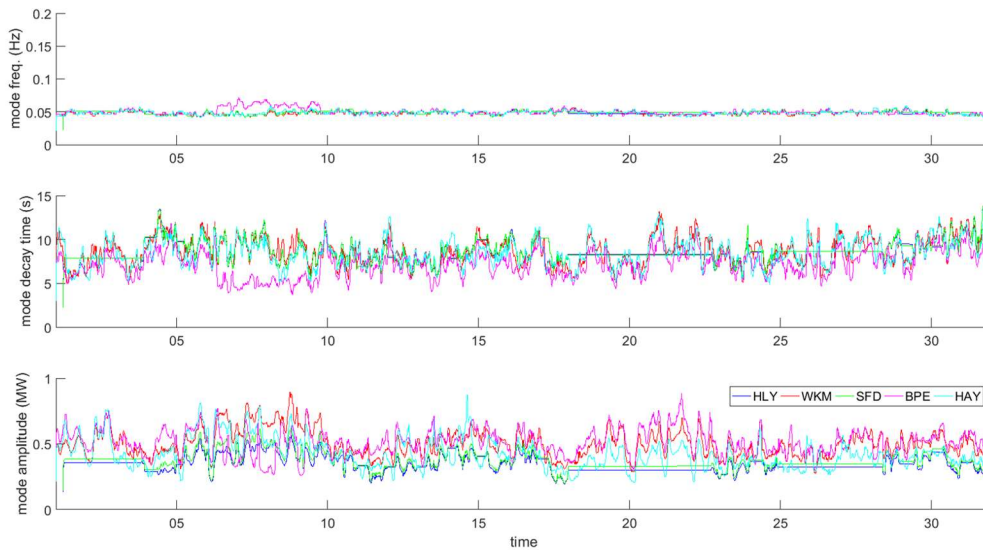


Figure 12: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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 ~27 mHz at certain period.

Using active power:

- 0.05 Hz mode is observed at most stations, except Bunnythorpe, where it increases to 0.06 Hz during certain periods.
- Decay time ranges from 5 seconds to 13 seconds for individual modes.
- Maximum oscillation amplitude ~800 kW.

3.4 Mode band 2: [0.2 – 0.6 Hz]

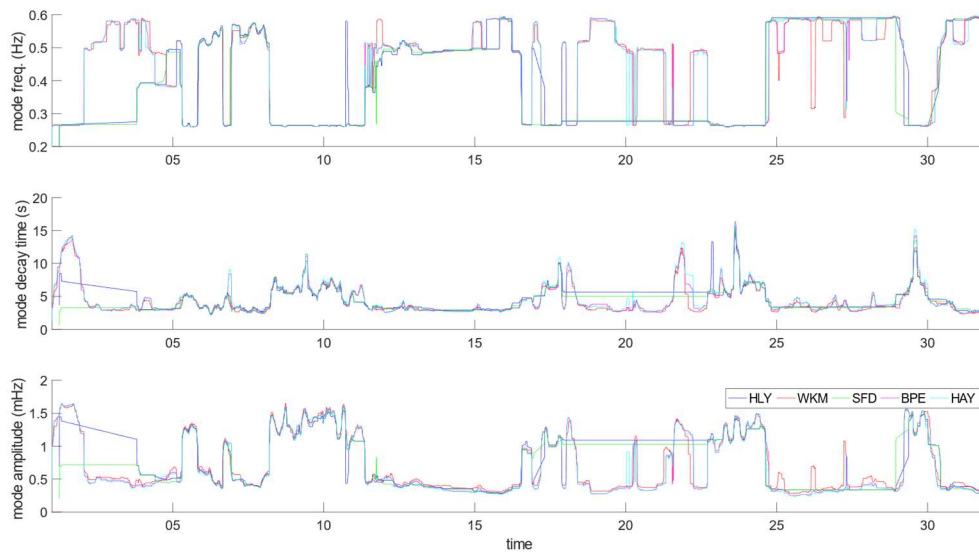


Figure 13: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

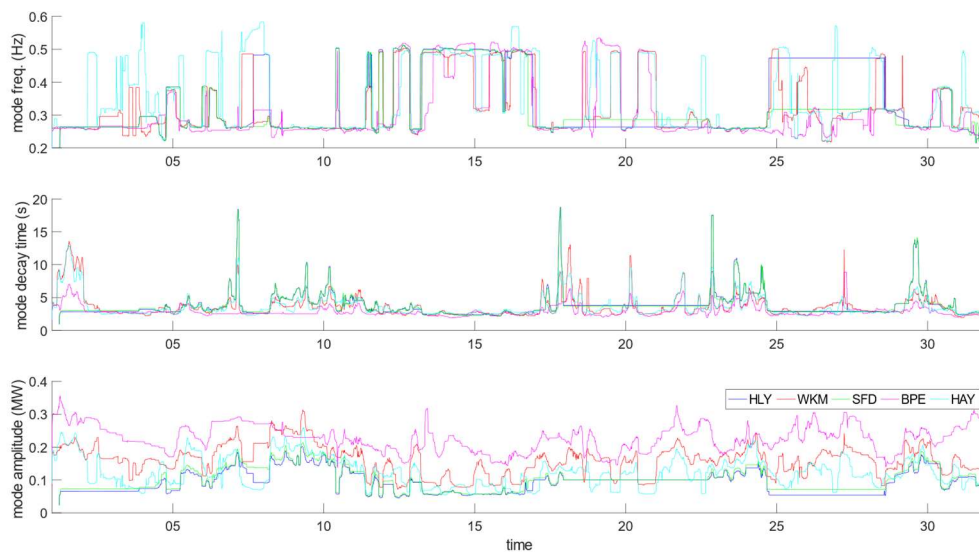


Figure 14: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency:

- 0.27 Hz, 0.5 Hz and 0.6 Hz modes observed at all stations. Decay time around 3-10 seconds, increasing to 10-17 seconds at certain periods for individual modes.

Using active power:

- 0.27 Hz and 0.5 Hz modes at most sites, ~0.6 Hz mode at Haywards at times..
- Decay time between 3-10 seconds, a peak decay of ~18 seconds observed at Stratford at certain periods.
- Maximum oscillation amplitude ~350 kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

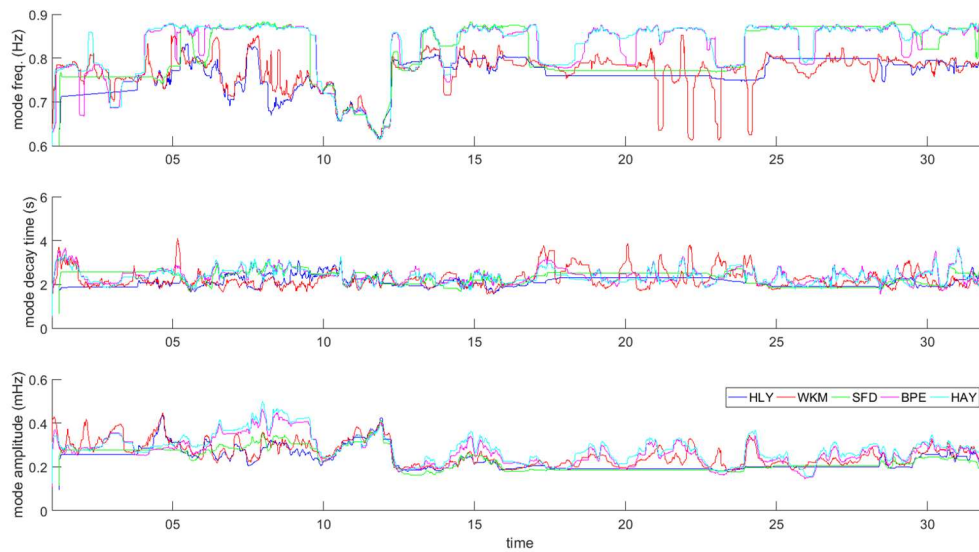


Figure 15: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

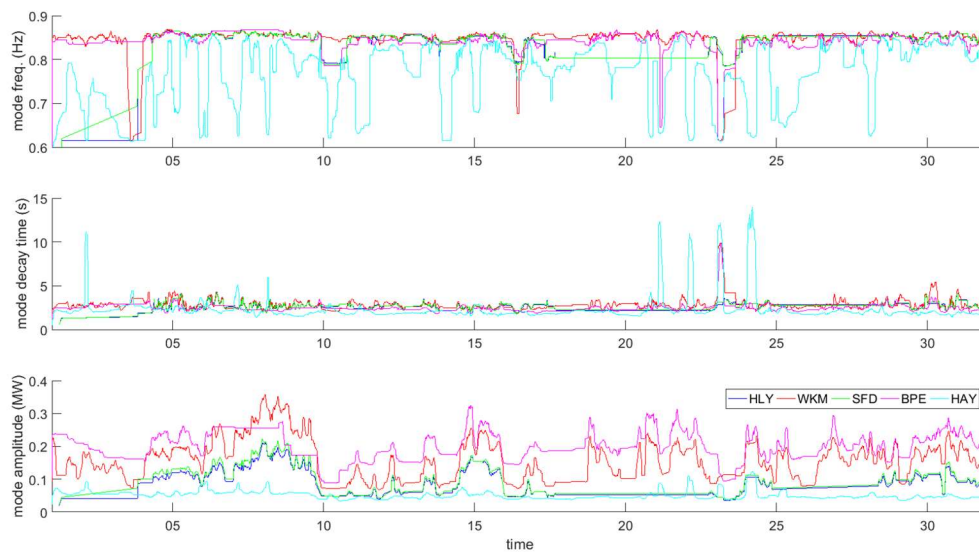


Figure 16: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Modes around 0.6 Hz, ~0.8 Hz, ~0.87 Hz observed.
- Decay time typically between 2-3 seconds at most sites occasionally peaking as high as 4 seconds at Whakamaru.
- Maximum amplitude ~0.45 mHz.

Using active power:

- Modes around 0.6 Hz, 0.80 Hz and 0.85 Hz observable.

- Decay time less than 5 seconds at most sites occasionally increasing to 13 seconds.
- Maximum amplitude at Whakamaru ~350 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

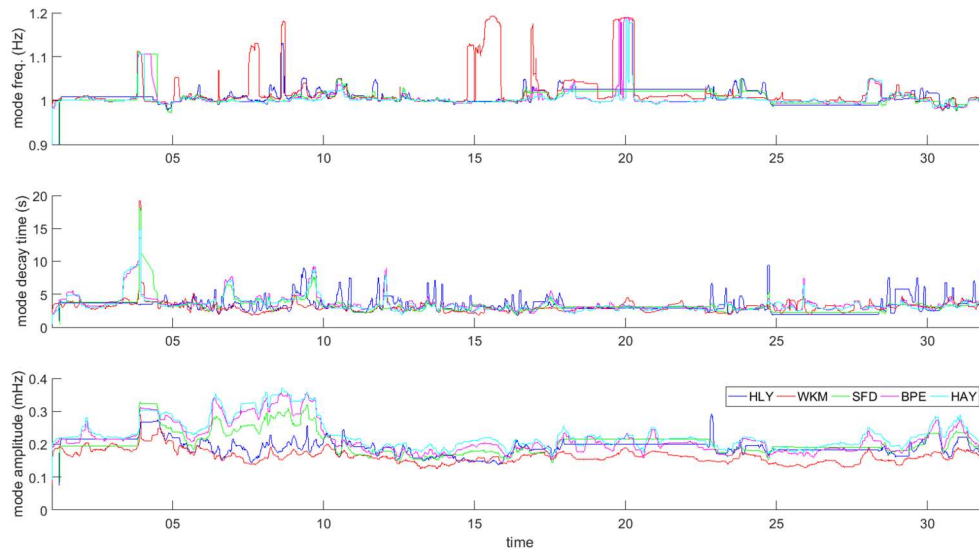


Figure 17: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

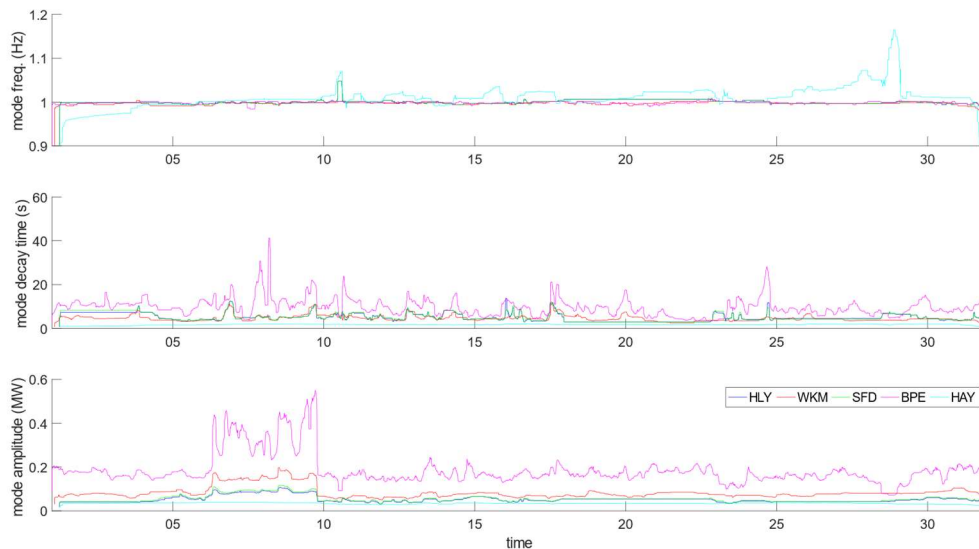


Figure 18: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at 1.00 Hz, 1.05 Hz, 1.10 Hz, 1.18 Hz.
- Most modes have decay times of under 10 seconds. However, Mode 1.00 Hz peaked around 20 seconds, as observed on the 4th of December.

Using active power:

- Most modes are typically well damped except for Bunnythorpe modes which exhibited a relatively high decay time around 10-20 seconds increasing to 40 seconds at certain periods.
- Most modes in this band have low oscillation amplitudes. The modes at Bunnythorpe have a maximum amplitude of ~550 kW but are usually lower at 200kW.

3.7 Mode band 5: [1.2 - 1.8 Hz]

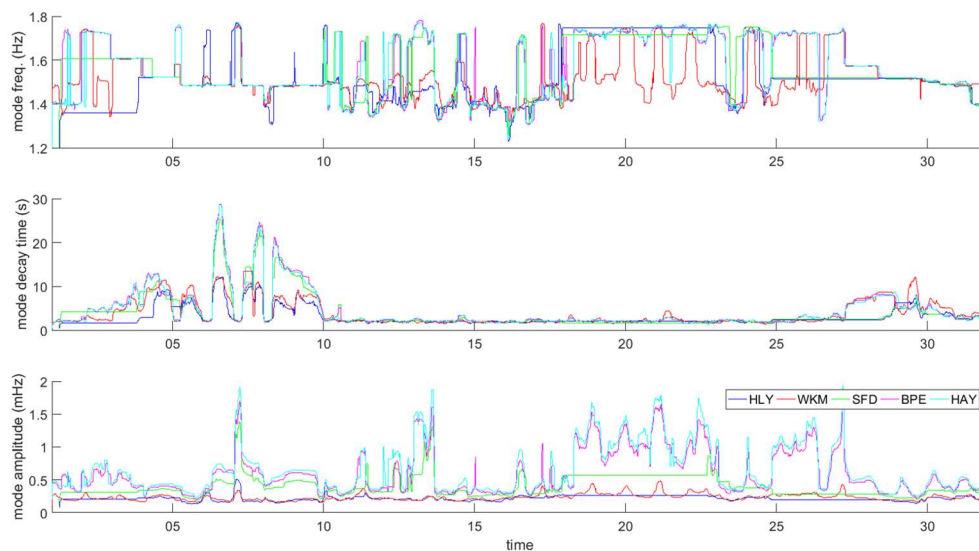


Figure 19: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

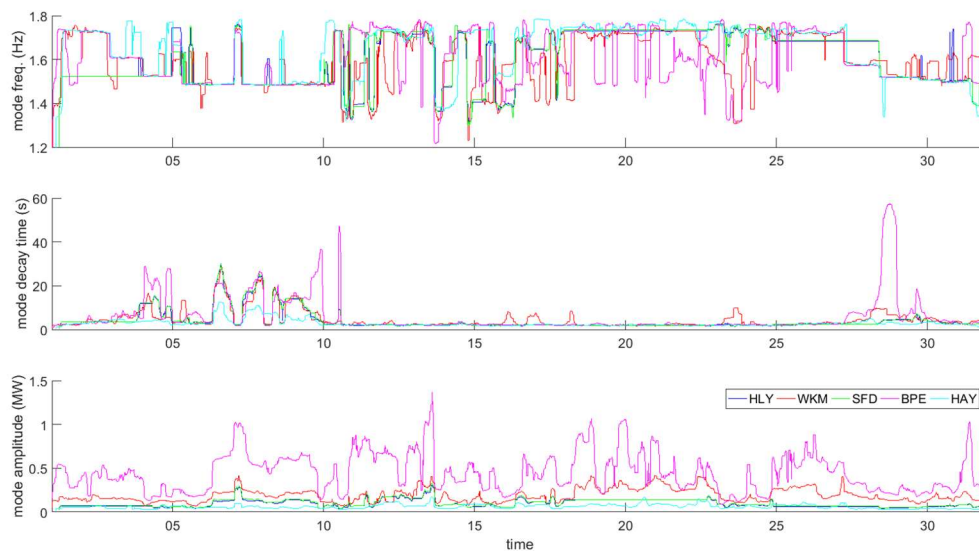


Figure 20: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes around ~1.4 Hz, 1.5 Hz, 1.6 Hz and ~1.7 Hz.
- Maximum decay time ~30 seconds for the 1.7 Hz mode. Most of the month the decay time is less than 10 seconds for other modes.
- Most mode amplitudes were observed to be less than 1 mHz throughout the month, except for the maximum amplitude observed at Bunnythorpe and Haywards, which was ~1.75 Hz.

Using active power:

- Most modes appear to be relatively well damped except mode 1.7 Hz where the peak decay time observed ~55 seconds at Bunnythorpe.
- Maximum amplitude ~1500 kW observed for 1.7 Hz at Bunnythorpe however appeared relatively well damped.

3.8 Mode band 6: [1.8 – 2.4 Hz]

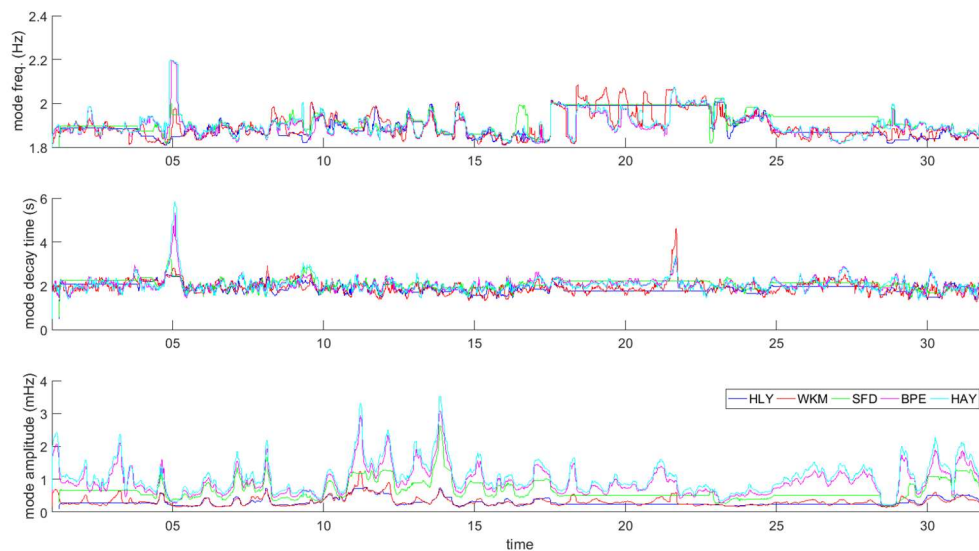


Figure 21: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

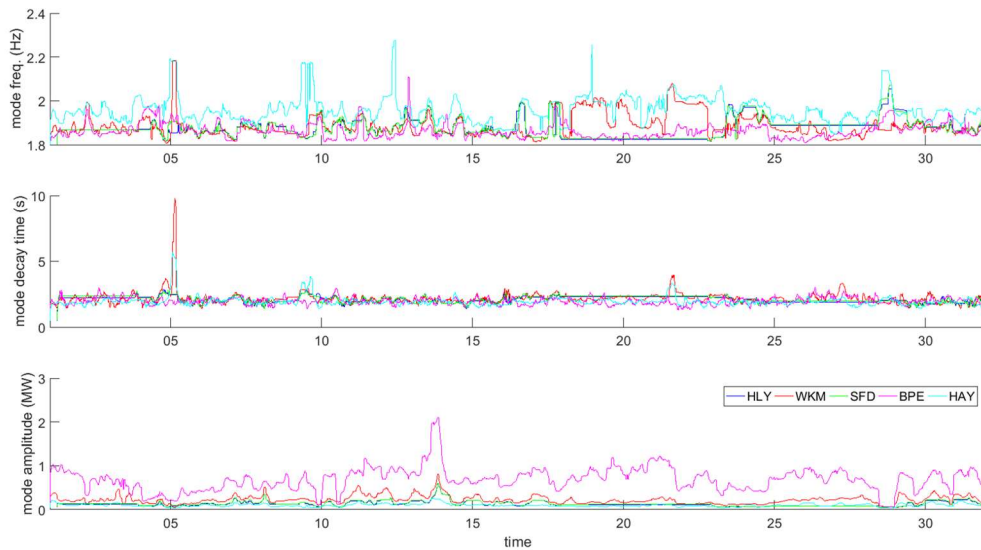


Figure 22: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes were observed at ~1.9 Hz and ~2 Hz at most sites, with an additional presence of 2.1 Hz at Whakamaru and occasionally 2.2 Hz at Haywards and Bunnythorpe.
- All modes in this frequency band are relatively well-damped.
- Maximum oscillation amplitude for this mode band ~3.5 mHz particularly visible at Haywards around the middle of the month.

Using active power:

- All modes in this frequency band are relatively well-damped. The decay time for the 2.2 Hz mode peaked at around 10 seconds on the 5th of December.
- The maximum oscillation amplitude for this mode band was ~2 MW at Bunnythorpe around the middle of the month.

3.9 Mode band 7: [2.4 – 4 Hz]

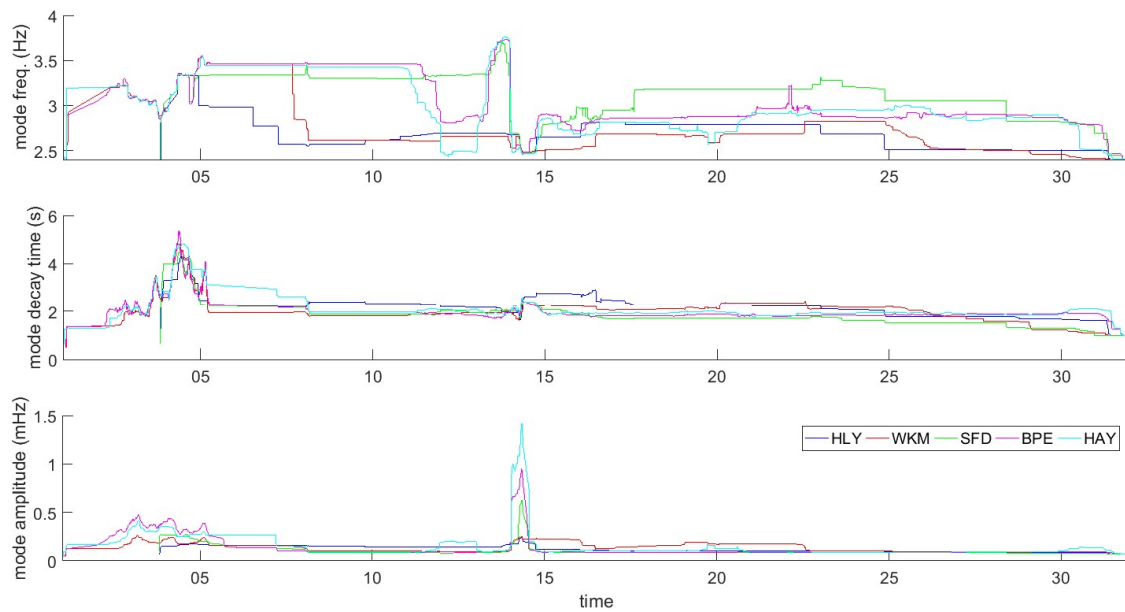


Figure 23: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

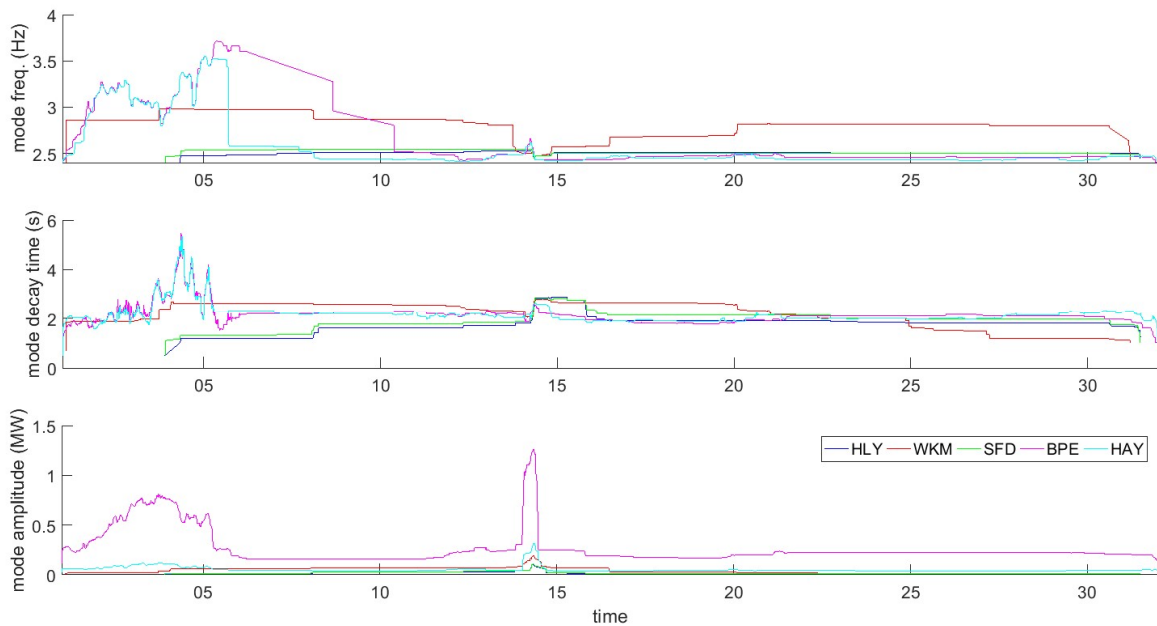


Figure 24: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Modes observed at 2.5 Hz, ~2.7 Hz, 3 Hz and 3.25 Hz.
- All modes in this band are relatively well-damped.

Using active power:

- Maximum oscillation amplitude for this mode band is 1.25 MW, visible briefly at Bunnythorpe on the 14th.