

DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – JANUARY 2023

Transpower New Zealand Limited

January 2023

Keeping the energy flowing



TRANSPOWER



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Version	Date	Change
1.0	01/12/2023	Final
	Position	Date
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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 January 2023. This monthly report presents these findings for January 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 January 2023
0.04 Hz	All-f All-p	Governor modes	Well-damped No significant change over the month
0.25 -0.30 Hz	All-f All-p	Probably control modes, and not electro-mechanical	Occurrences of low damping periods High decay time in certain periods
0.5 – 0.6 Hz	All-f Most-p	Possibly Inter area modes	Decay time up to 15s
0.7-1.0 Hz	All-f All-p	Inter-area and Inter-station modes	Relatively well damped Low amplitude
1.7-1.9 Hz	All-f All-p	Inter-station and Local modes	Relatively high number of occurrences Periods of relatively high amplitude
2.4 Hz	All-f All-p	Not yet identified	Low number of occurrences Periods of high amplitude Well damped
3, 3.5 Hz	Most-f Most-p	Not yet identified	Low number of occurrences Low amplitude

The Wairakei PMU was disconnected from the start of 2023 through to 5th October.

3 Detailed plots for January 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

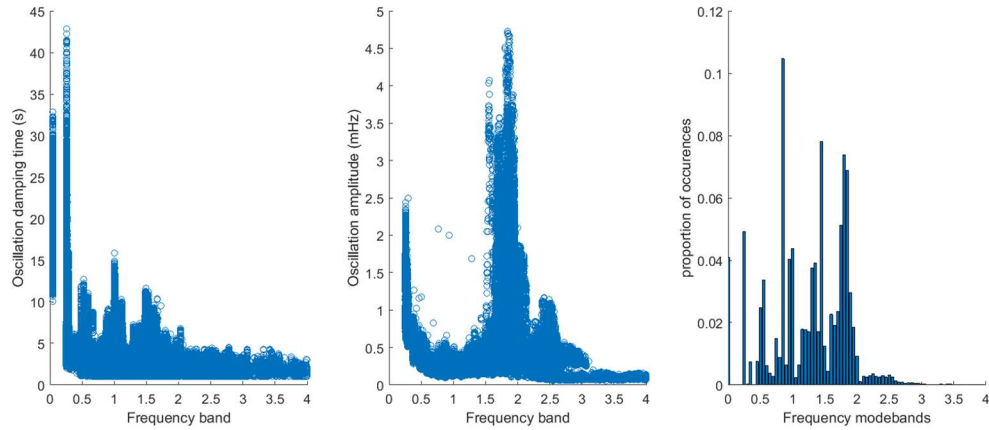


Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

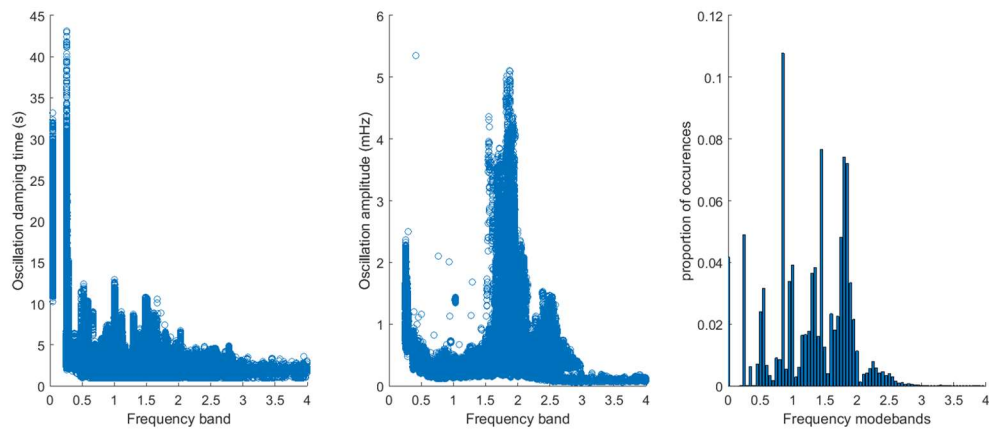


Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

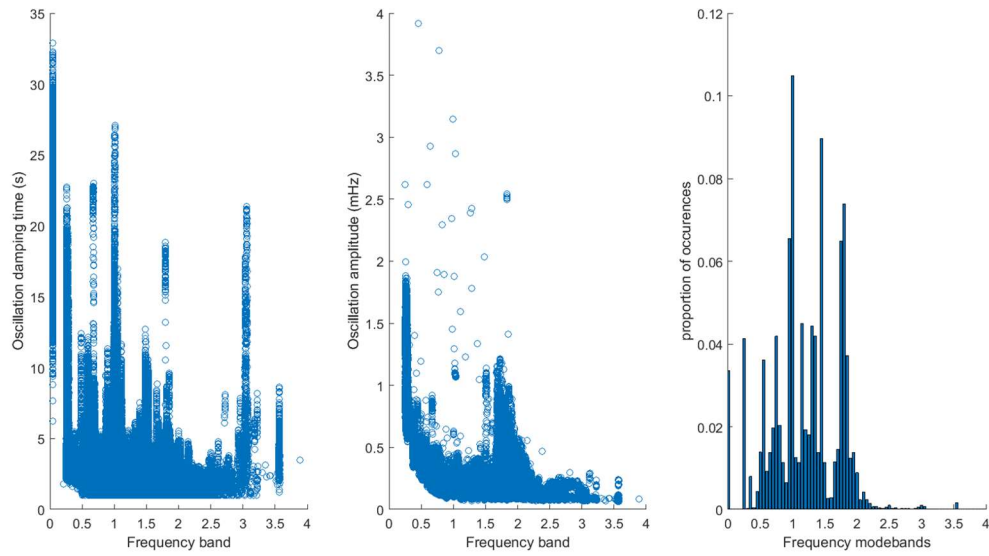


Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

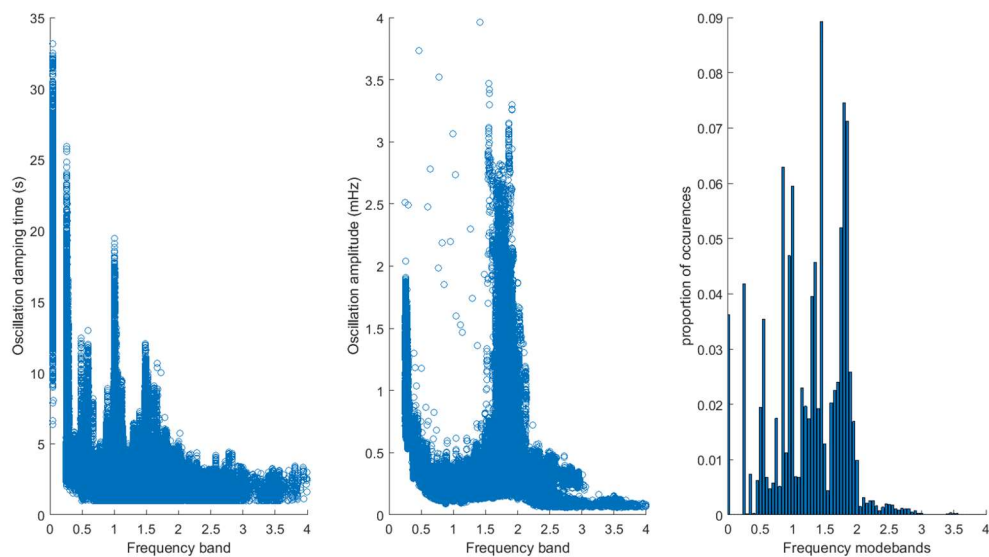


Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

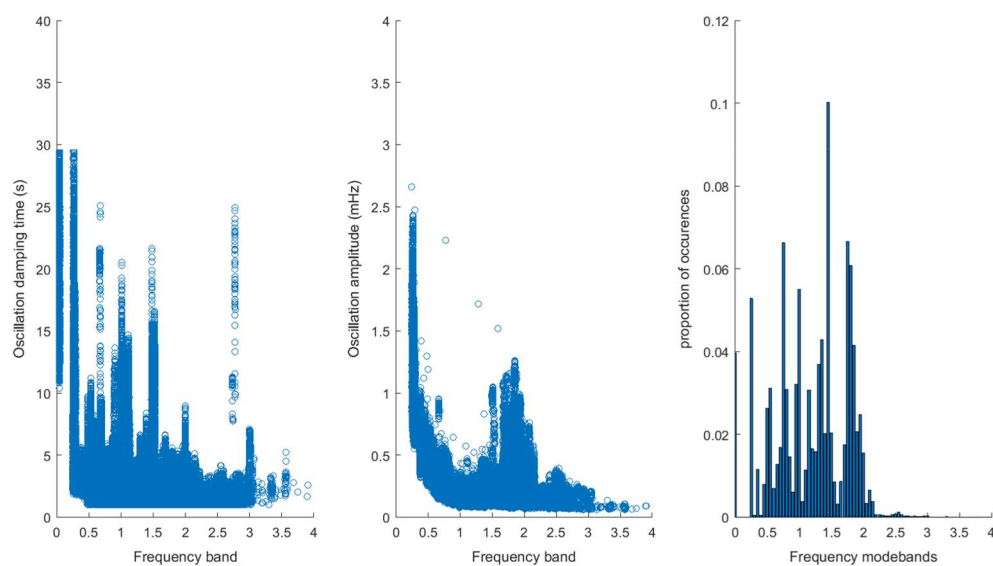


Figure 5: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

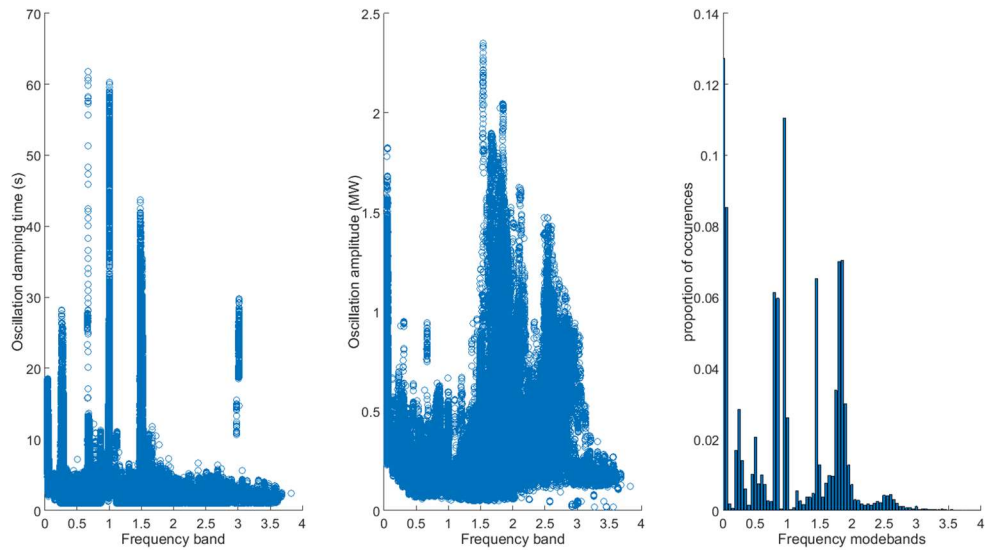


Figure 6: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

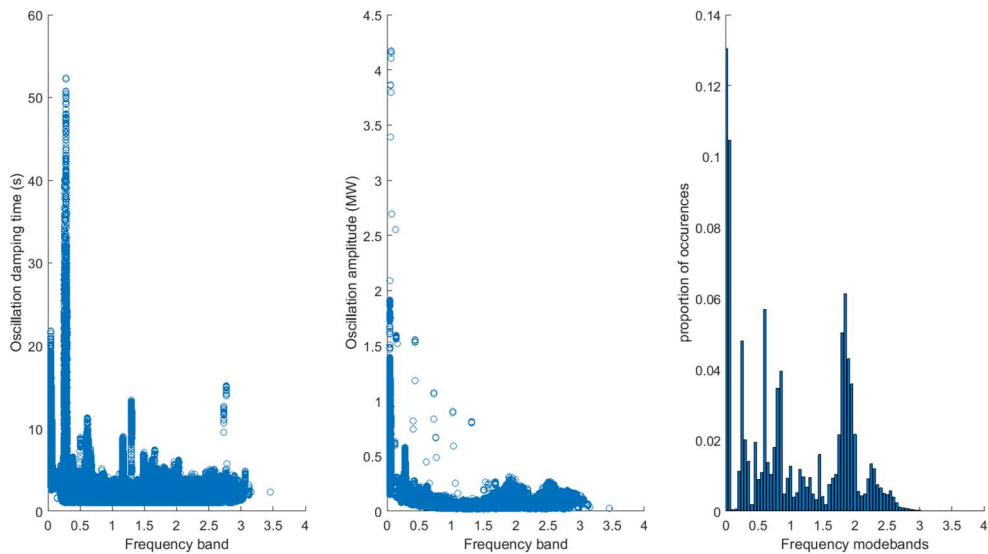


Figure 7: Haywards mode damping, mode amplitude, and frequency histogram using active power data

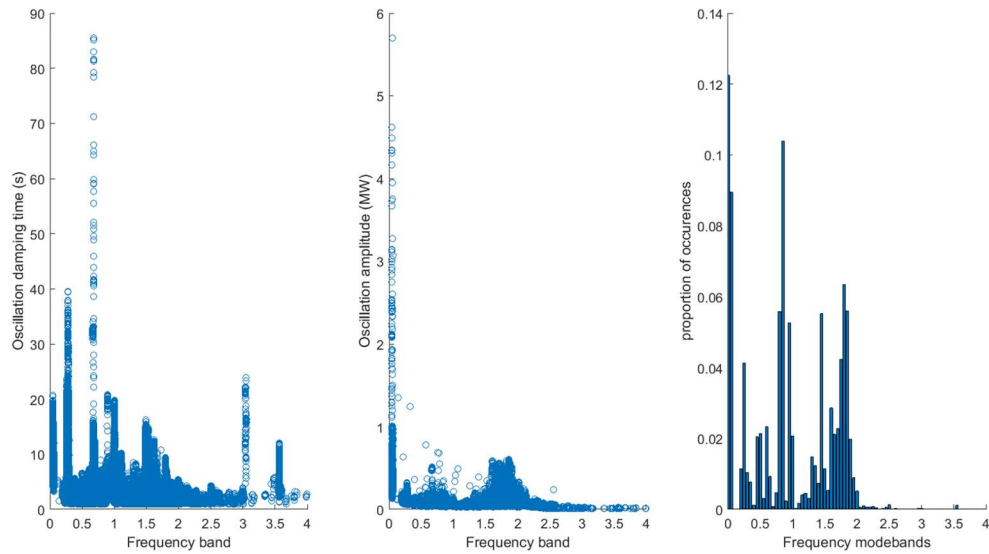


Figure 8: Huntly mode damping, mode amplitude, and frequency histogram using active power data

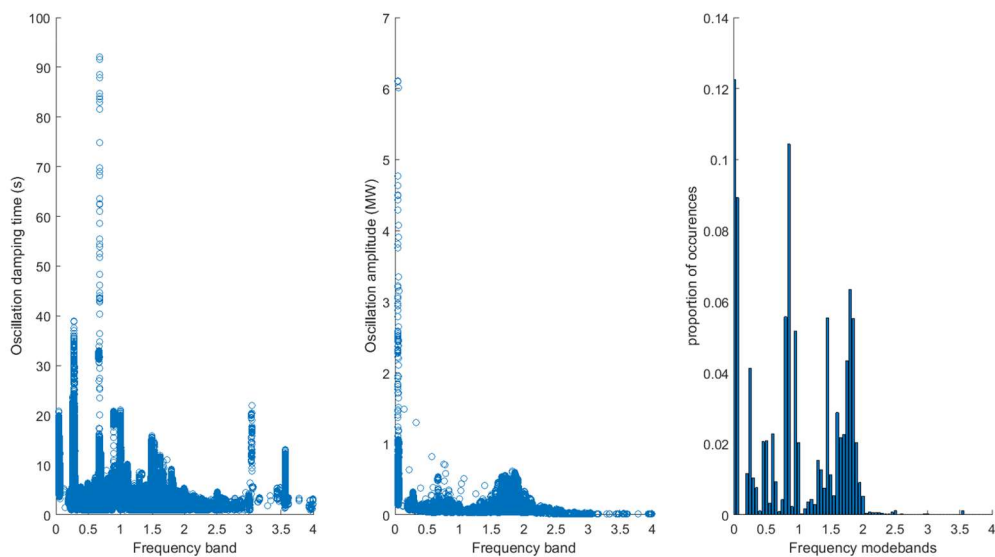


Figure 9: Stratford mode damping, mode amplitude, and frequency histogram using active power data

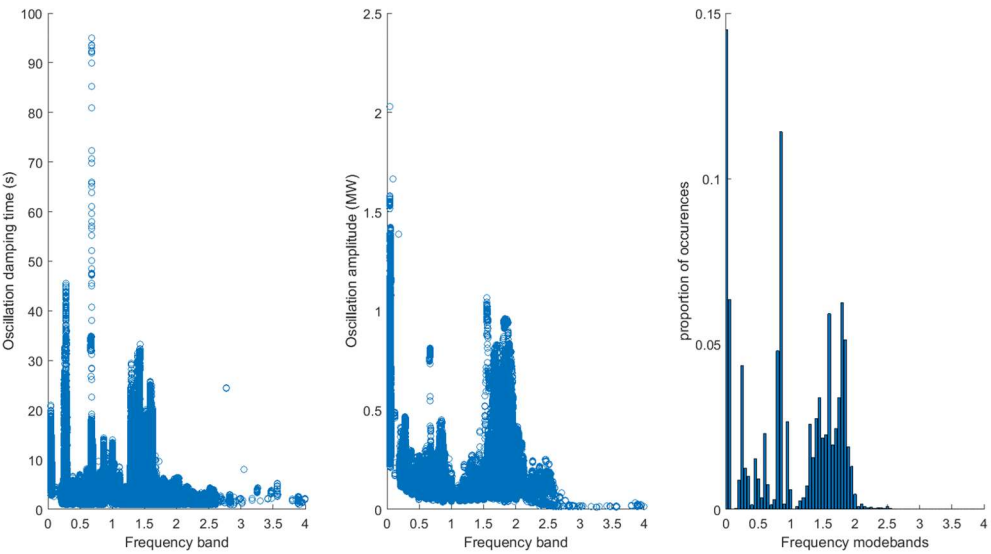


Figure 10: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

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 1.8 Hz can be observed in the January data, particularly at Bunnythorpe.

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
- 0.6 Hz
- 1.0 Hz
- 1.5 Hz
- 1.8 Hz
- 3, 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]

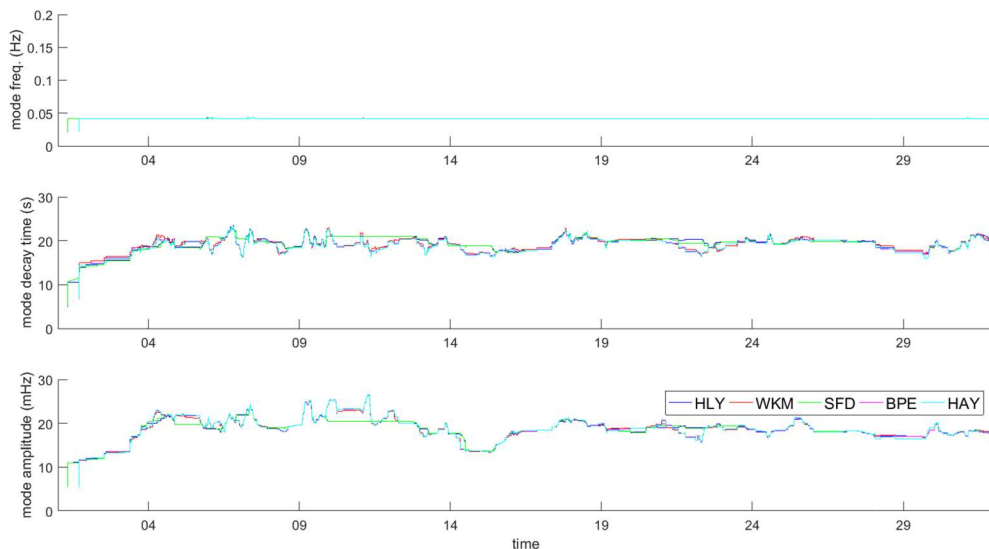


Figure 11: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

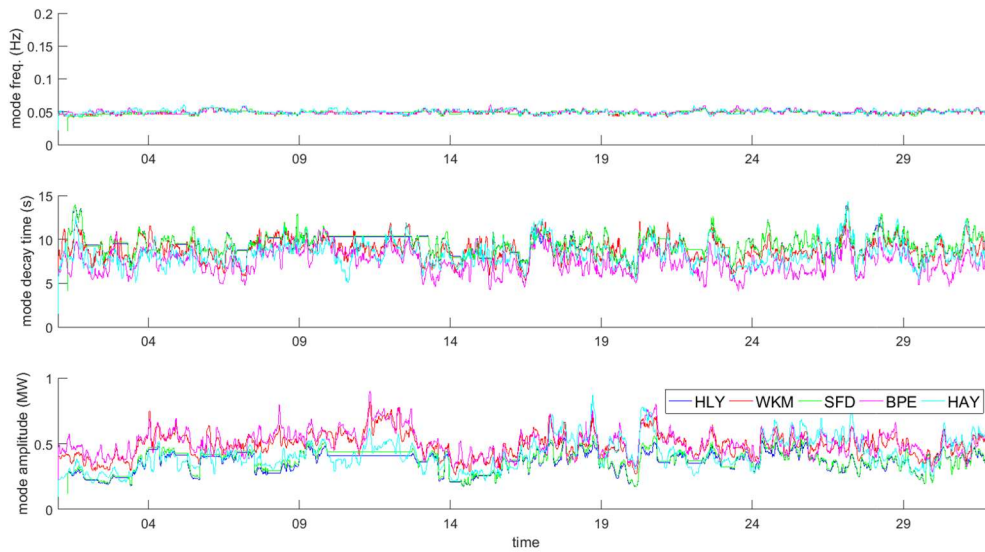


Figure 12: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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 ~25 mHz at certain period.

Using active power:

- 0.05 Hz mode at all substations.
- 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]

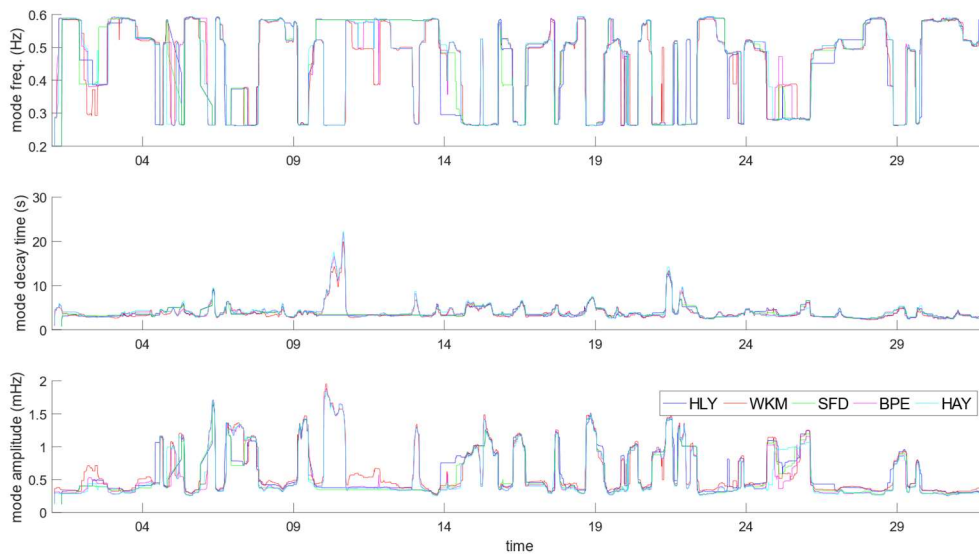


Figure 13: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

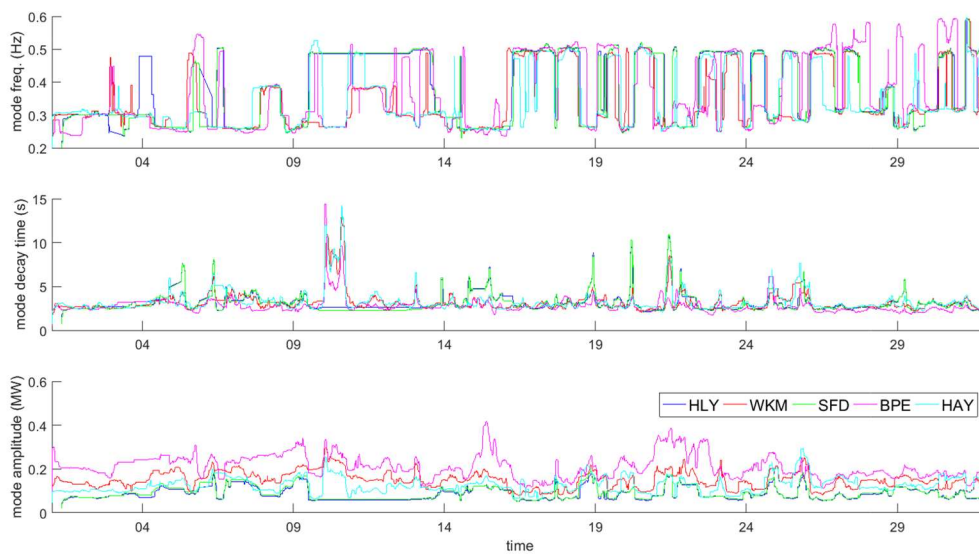


Figure 14: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency

- 0.30 Hz mode. Decay time usually around 3 seconds, increasing to 10-20 seconds at times throughout the month.
- 0.5 Hz-0.6 Hz, decay time around 5-10 seconds throughout the month.

Using active power:

- 0.25 Hz, 0.5 Hz modes at most sites, low amplitude.
- 0.25 Hz mode decay around 3-5 seconds when dominant.

- 0.5-0.6 Hz mode decay time between 3-15 seconds.
- Maximum oscillation amplitude ~400kW, typically 200kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

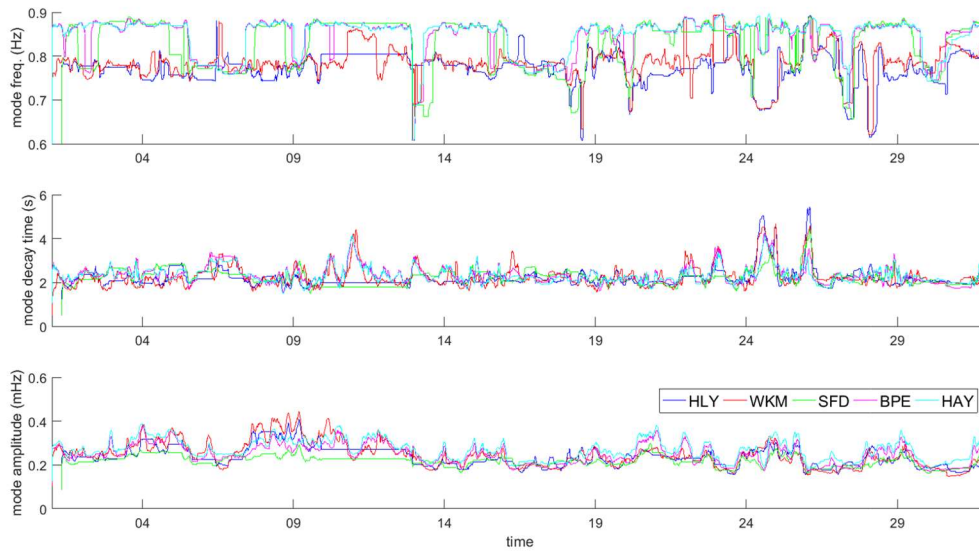


Figure 15: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

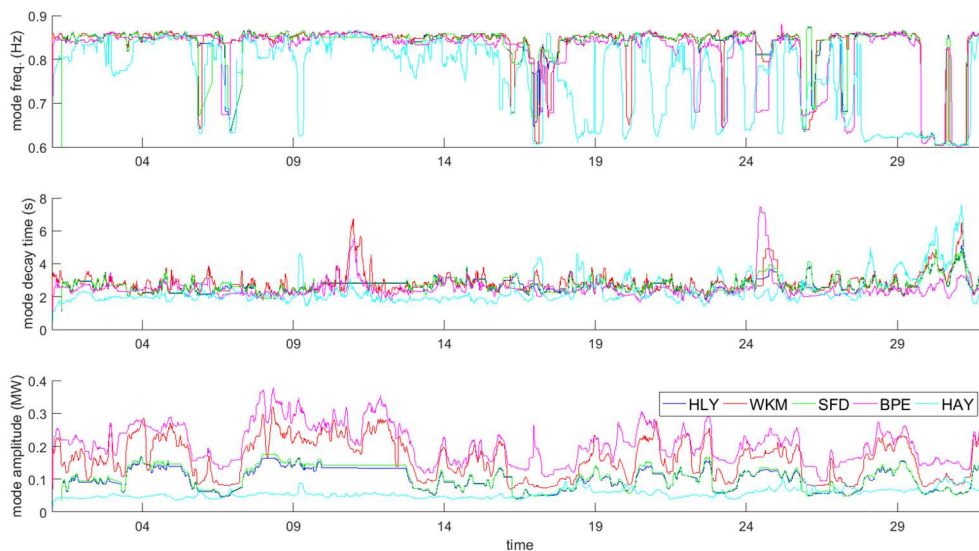


Figure 16: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Mode around ~0.6 Hz (rarely), normally 0.7 Hz – 0.87 Hz observed.
- Decay time typically less than 4 seconds at most sites occasionally peaking as high as 5 seconds.

- Maximum amplitude ~ 0.45 mHz.

Using active power

- Modes around ~ 0.6 Hz (briefly, mainly at HAY), usually 0.85 Hz dominant elsewhere.
- Decay time less than 8 seconds at all sites.
- Maximum amplitude at Bunnythorpe ~ 400 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

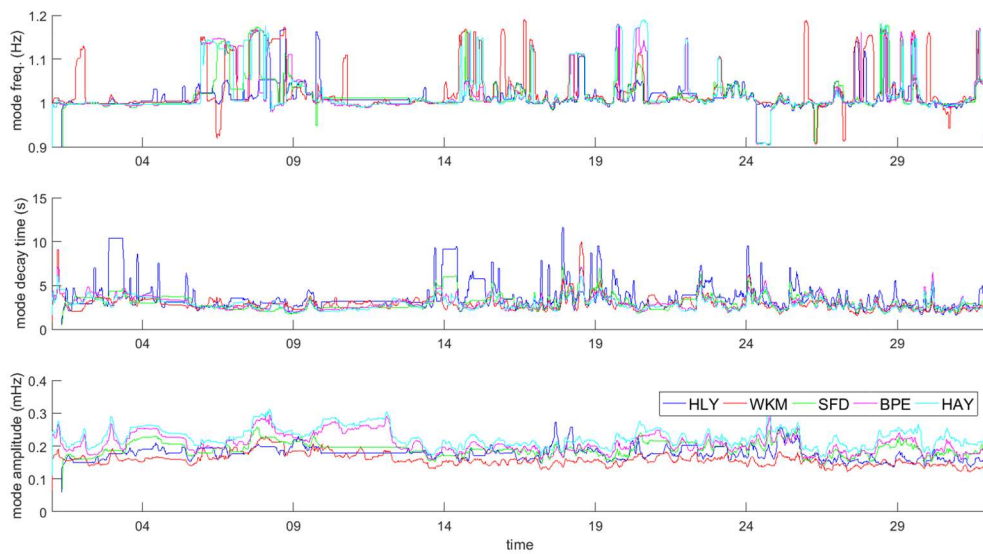


Figure 17: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

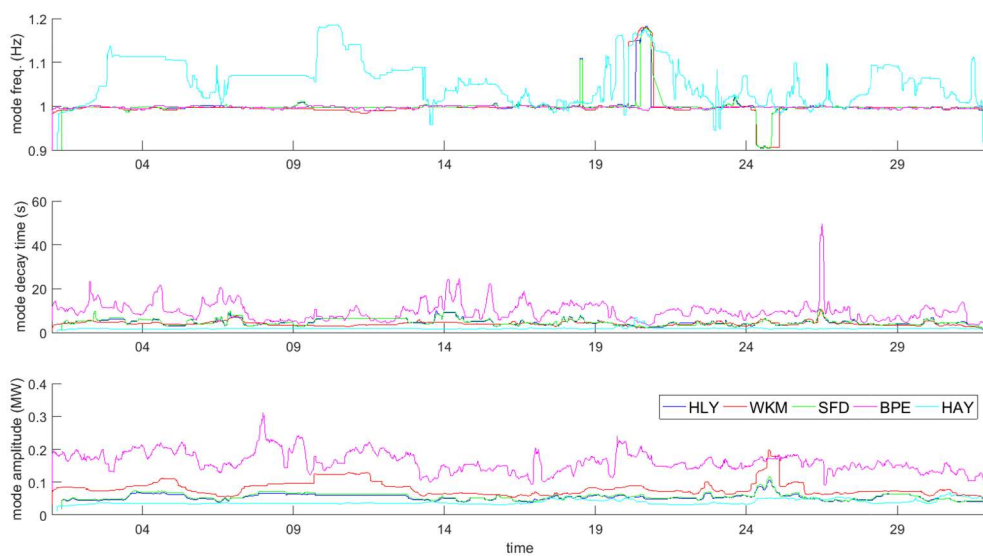


Figure 18: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at ~0.93 Hz, 1.0 Hz(most common), 1.05 Hz, 1.10 Hz and 1.18 Hz.
- Highest mode amplitude occurring at Haywards for various frequencies. Most decay times are under 5 seconds.
- Mode 1.05 Hz peaks around 12 seconds observed from Huntly at certain periods.

Using active power

- Most modes are typically well damped. However, towards the end of the month, the 1 Hz mode at Bunnythorpe shows a decay time up to 50 seconds. This was very low magnitude (200kW), it was reported as poorly damped for a period of around 3 hours.
- Most modes in this band have low oscillation amplitudes. The maximum amplitude observed was 300 KW at Bunnythorpe, which is still relatively low.

3.7 Mode band 5: [1.2 - 1.8 Hz]

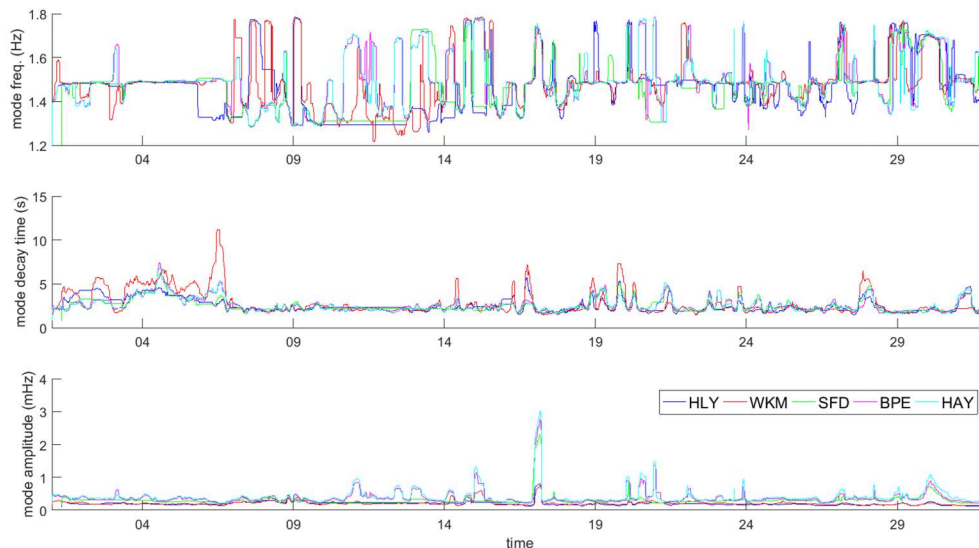


Figure 19: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

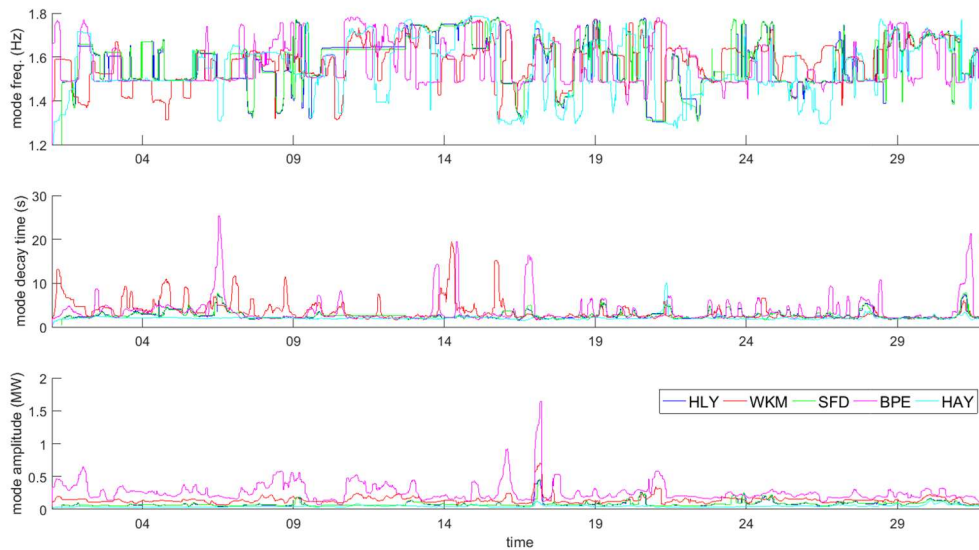


Figure 20: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes around ~1.3 Hz, 1.5 Hz, and ~1.8 Hz.
- Maximum decay time ~12 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 Stratford, Bunnythorpe and Haywards for ~1.8 Hz. Most mode amplitude was observed to be less than 1 mHz throughout the month.

Using active power

- Most modes appear to be relatively well damped except mode ~1.8 Hz where the peak decay time observed ~25 seconds at Bunnythorpe at certain periods.
- Maximum amplitude ~1.5 MW observed for 1.8 Hz at Bunnythorpe however appeared relatively well damped.

3.8 Mode band 6: [1.8 – 2.4 Hz]

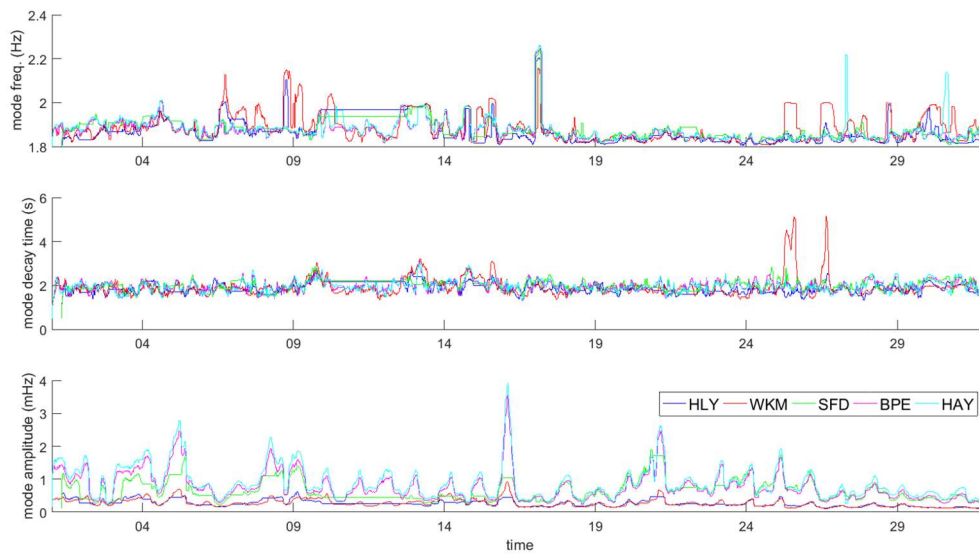


Figure 21: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

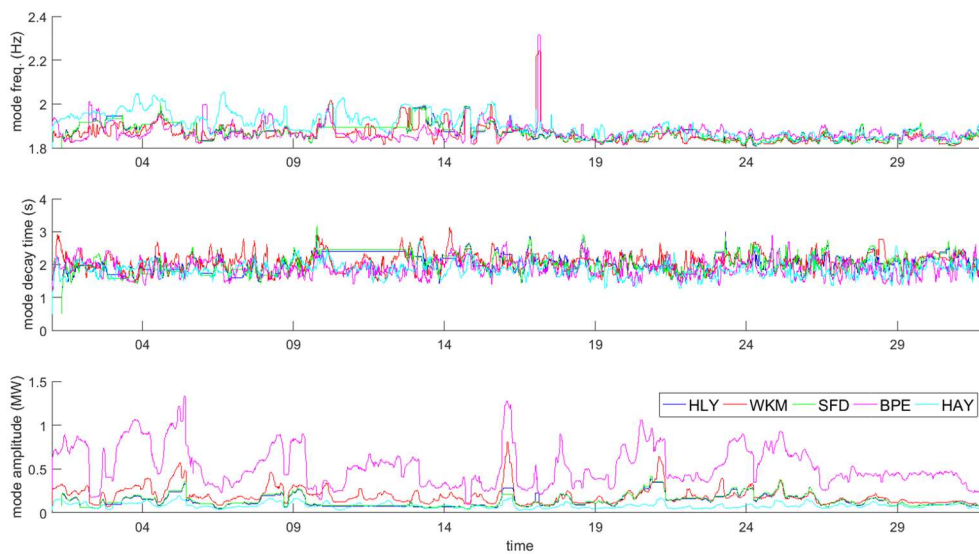


Figure 22: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- All modes in this band are relatively well-damped.
- Mode 2 Hz decay time peaked at around 5 seconds towards the end of the month.
- There was a mode with relatively high amplitude around the 16th of January at a frequency of ~1.9 Hz particularly visible at Haywards and Bunnythorpe.

Using active power

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

- Maximum oscillation amplitude for this mode band ~1.25 MW particularly visible at Bunnythorpe (between 1.8 and 1.9 Hz) throughout the month.

3.9 Mode band 7: [2.4 – 4 Hz]

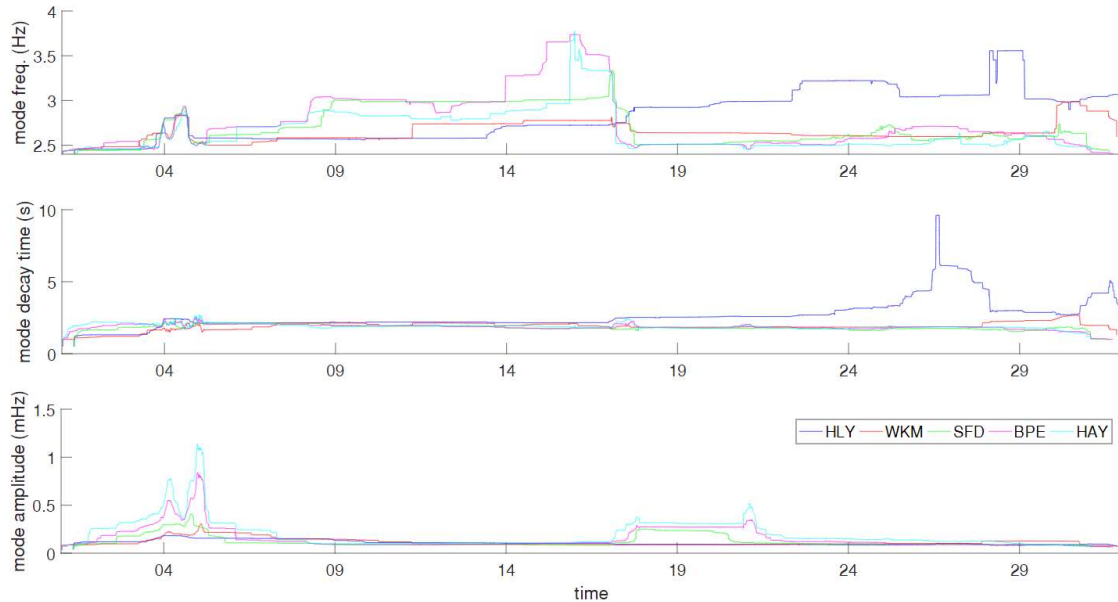


Figure 25: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

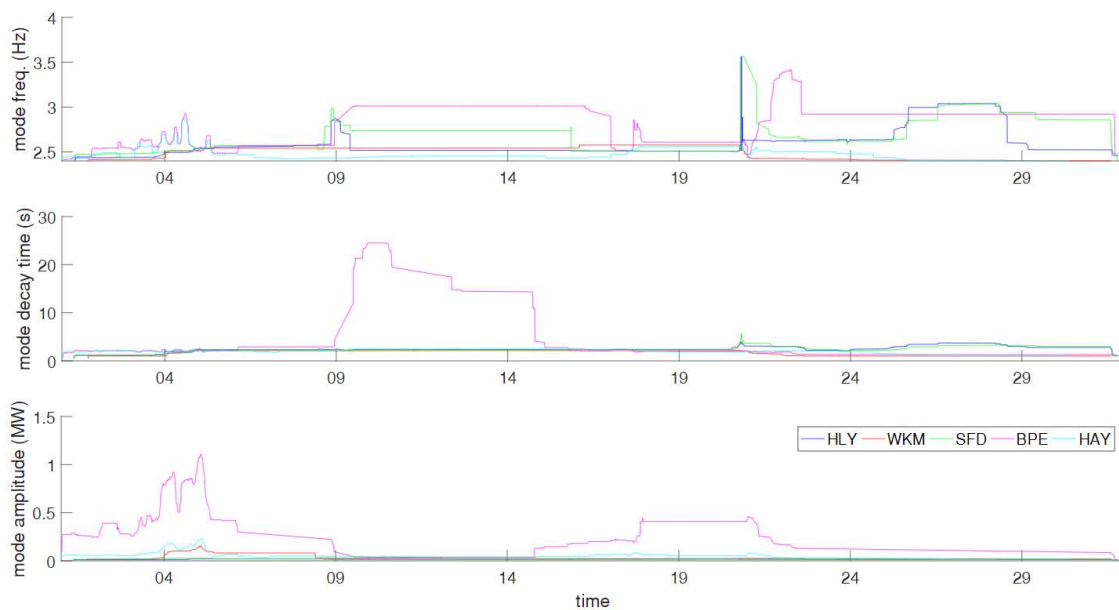


Figure 26: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Modes observed at 2.5 Hz, ~2.7 Hz, 3 Hz and 3.5-3.7 Hz.
- All modes in this band are relatively well-damped in the frequency data.

Using active power:

- Maximum decay time for this mode band is 20 seconds, visible at Bunnythorpe for the 3 Hz mode, but at very low amplitude.

Maximum oscillation amplitude for this mode band is ~1 MW, visible at Bunnythorpe for frequencies closer to 2.5Hz, these are well damped.