

DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – NOVEMBER 2022

Transpower New Zealand Limited

November 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 November 2022. This monthly report presents these findings for November 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 November 2022
0.04 Hz	All-f All-p	Governor modes	No significant change over the month
0.25 Hz	All-f BPE-p	Probably control modes, and not electro-mechanical	Relatively high number of occurrences Low damping High amplitude in frequency data
0.5 – 0.6 Hz	All-f Most-p	Possibly Inter area modes	Typically well damped
0.8-1 Hz	All-f All-p	Inter-area and Inter-station modes	High number of occurrences Decay time up to 25 seconds in power data Relatively low amplitude
1.5 Hz	Most-f Most-p	Inter-station and Local modes	Relatively high number of occurrences Decay time up to 30 seconds Low amplitude
1.7-1.9 Hz	All-f BPE-p WKM-p	Inter-station and Local modes	High number of occurrences High oscillation amplitude in the middle of the month Mostly well damped

2.5, 3, 3.5 Hz	Most-f, BPE-f & HAY-f, SFD-f	Not yet identified	Low number of occurrences Well damped
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The 2.5 Hz oscillations that were observed as poorly damped last month have occurred only rarely this month.

3 Detailed plots for November 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

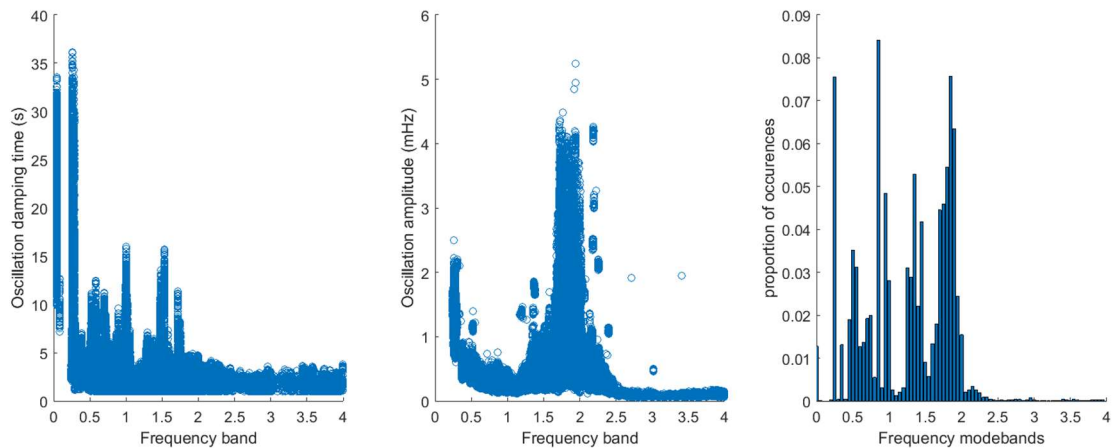


Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency bands data

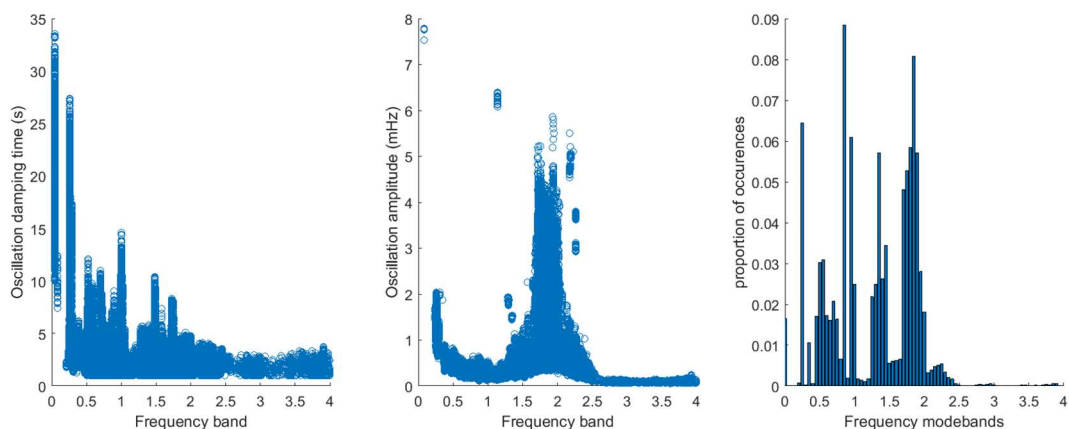


Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency bands data

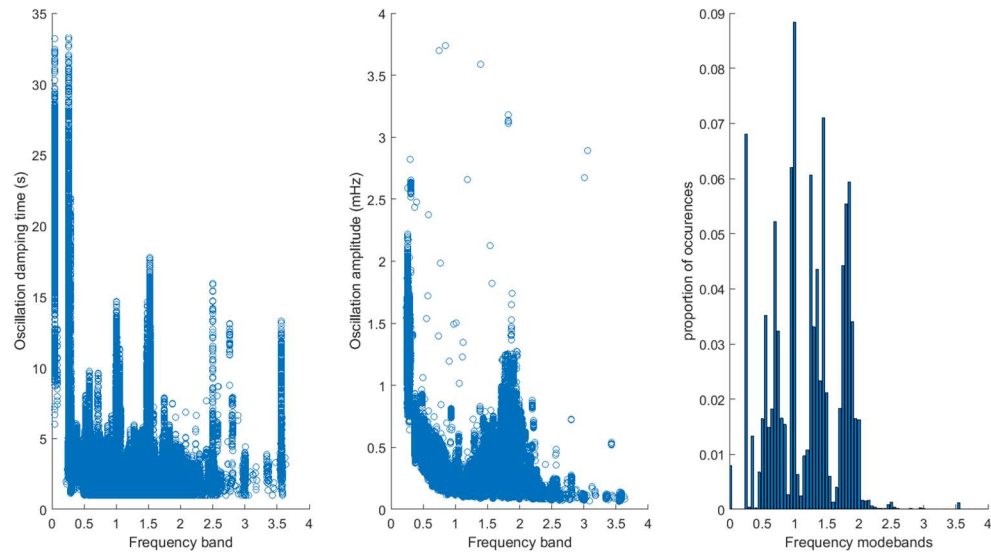


Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

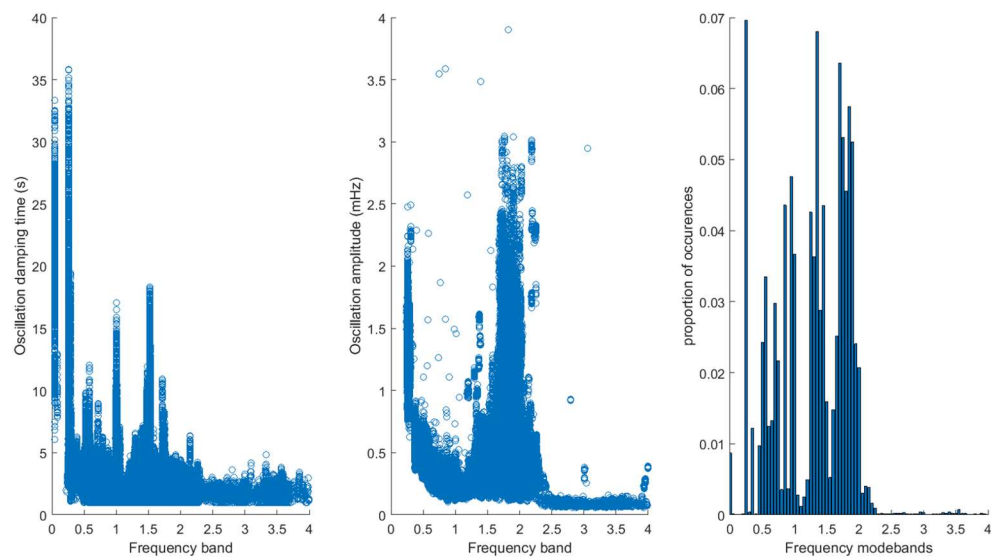


Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

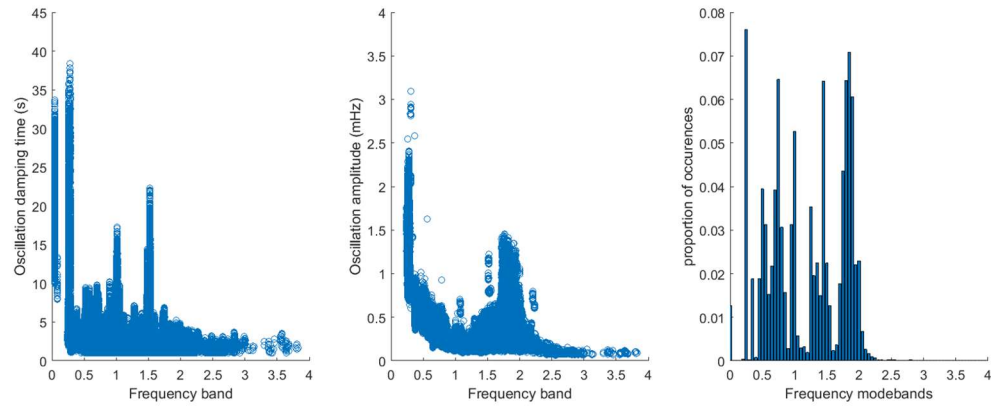


Figure 5: Wairakei mode damping, mode amplitude, and frequency histogram using frequency data

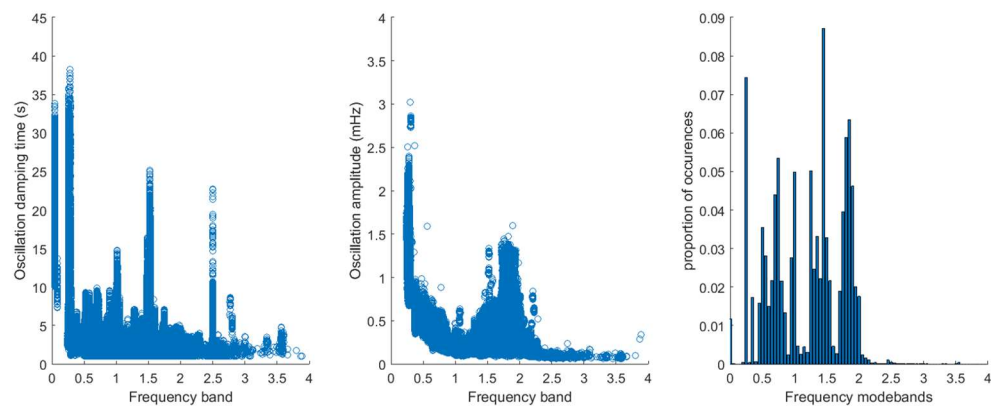


Figure 6: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

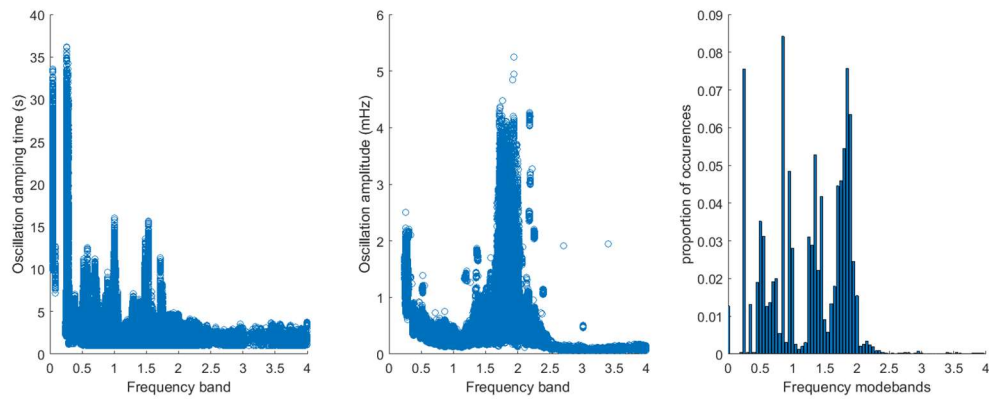


Figure 7: Bunnythorpe mode damping, mode amplitude, and frequency histogram using active power data

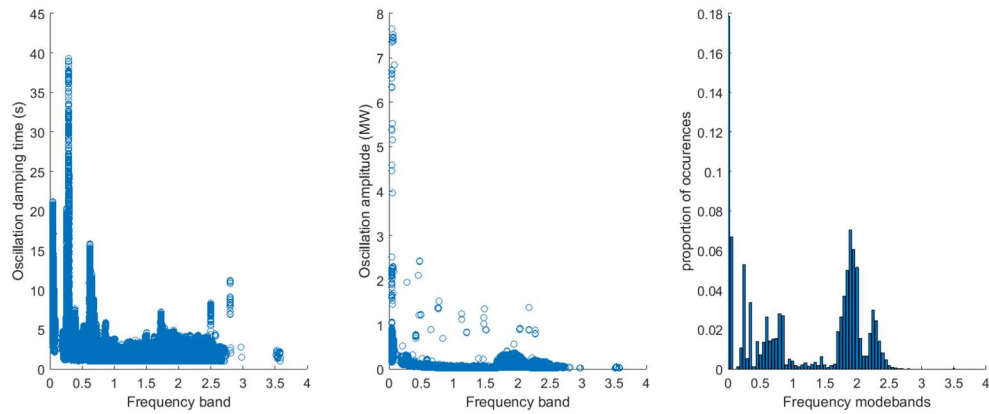


Figure 8: Haywards mode damping, mode amplitude, and frequency histogram using active power data

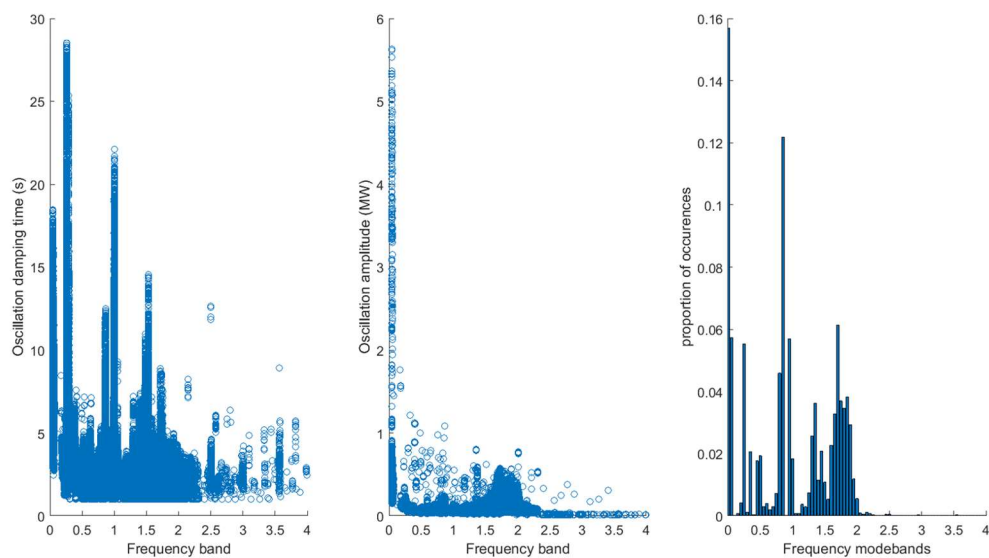


Figure 9: Huntly mode damping, mode amplitude, and frequency histogram using active power data

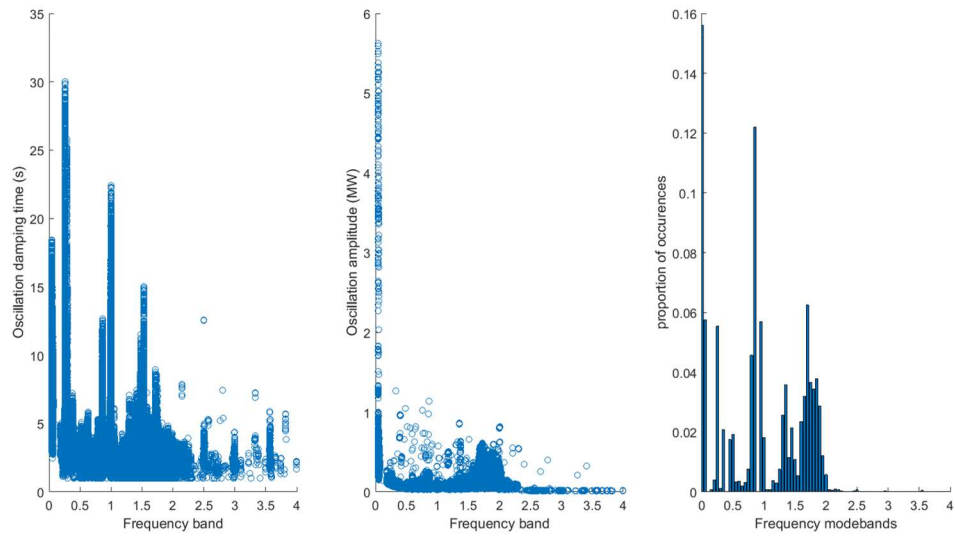


Figure 10: Stratford mode damping, mode amplitude, and frequency histogram using active power data

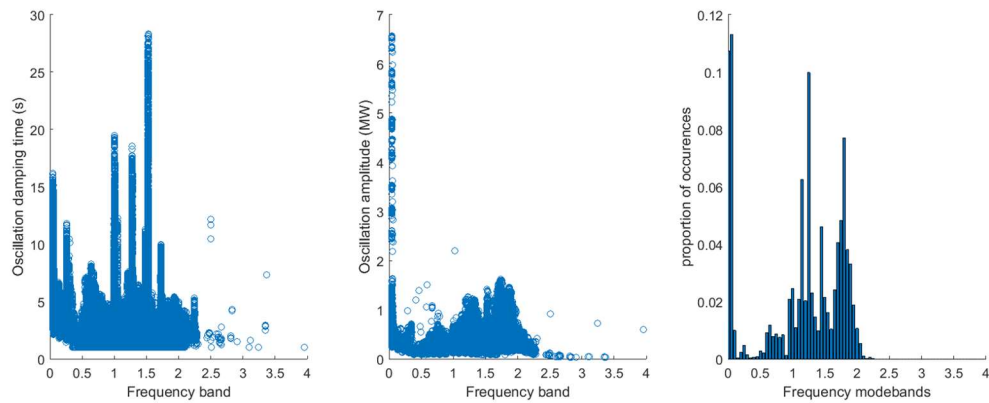


Figure 11: Wairakei mode damping, mode amplitude, and frequency histogram using active power data

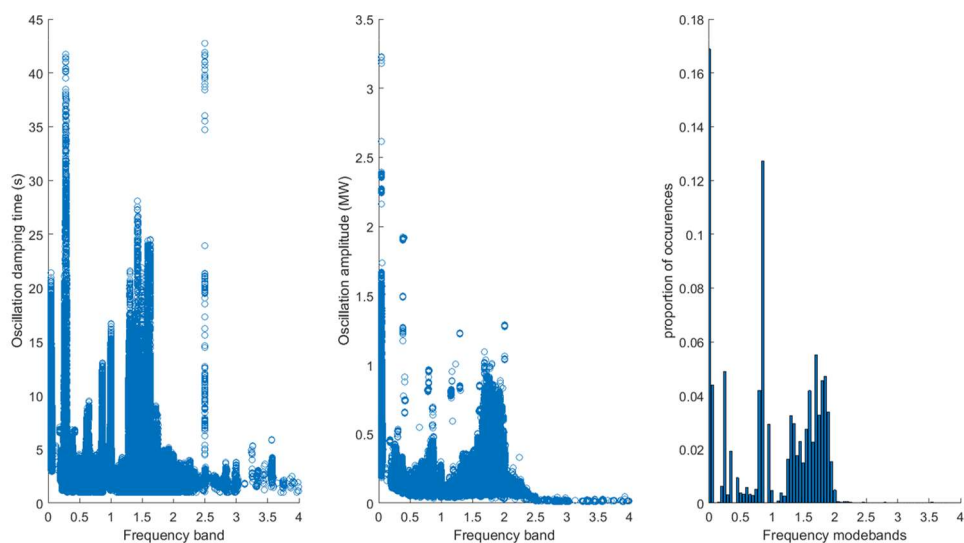


Figure 12: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

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 to 1.9 Hz can be observed in the November 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 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]

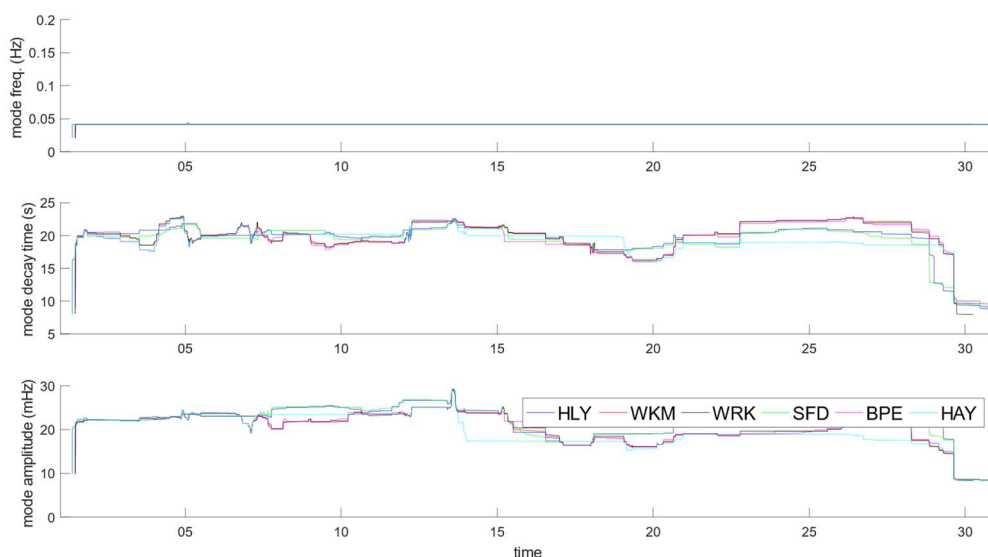


Figure 13: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

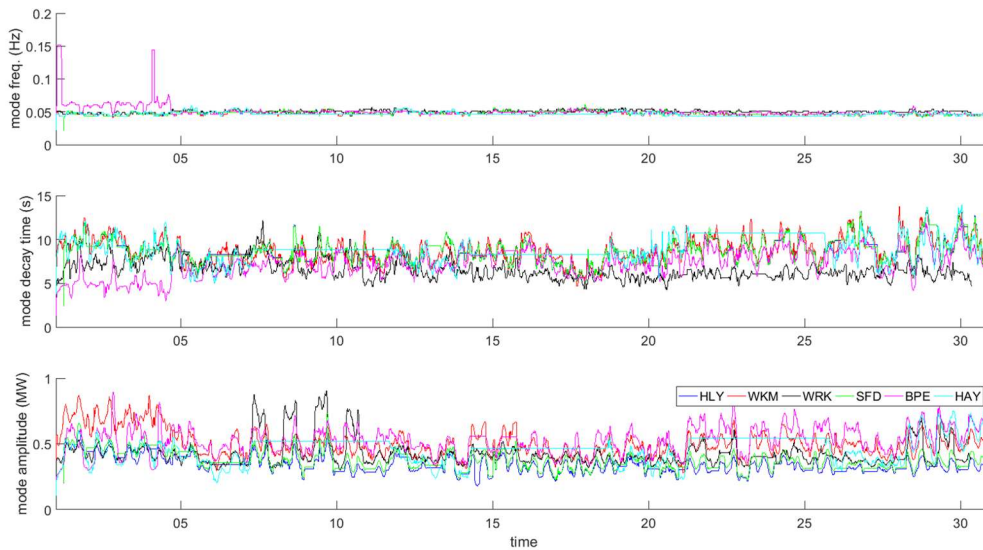


Figure 14: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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.
- Maximum oscillation amplitude ~30 mHz.

Using active power:

- 0.05 Hz mode at all substations. Mode at 0.15 Hz also observed at Bunnythorpe at the start of the month.
- Decay time ranges from 5 seconds to 15 seconds for individual modes.
- Maximum oscillation amplitude ~900 kW.

3.4 Mode band 2: [0.2 – 0.6 Hz]

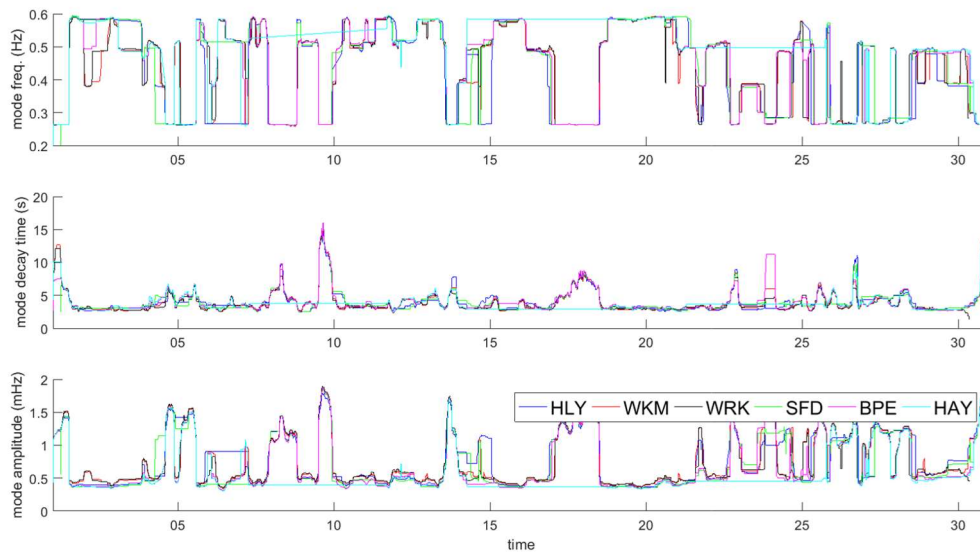


Figure 15: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

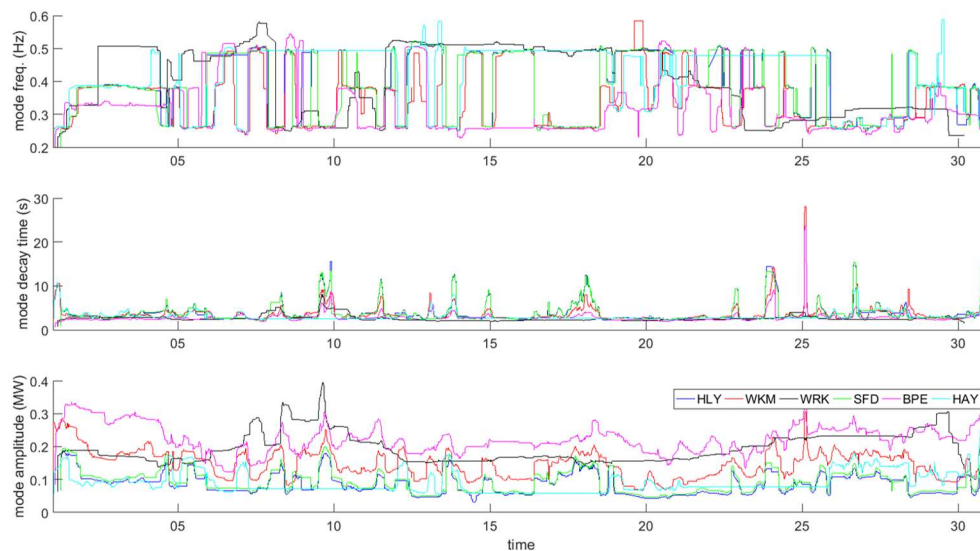


Figure 16: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency:

- 0.25 Hz and 0.5 Hz, 0.6 Hz modes observed at all stations. Decay time around 5-15 seconds.

Using active power:

- 0.25 Hz mode observed at most stations, and ~0.4 Hz, 0.5 Hz modes observed at certain stations.
- Decay time around 5-15 seconds, increasing to 30 seconds at Bunnythorpe for the 0.25 Hz mode.
- Maximum oscillation amplitude ~400 kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

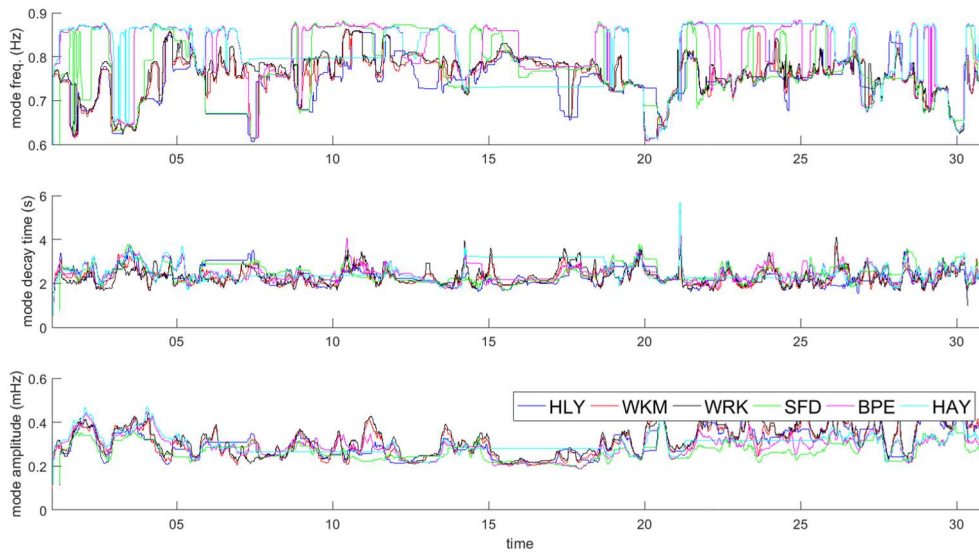


Figure 17: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

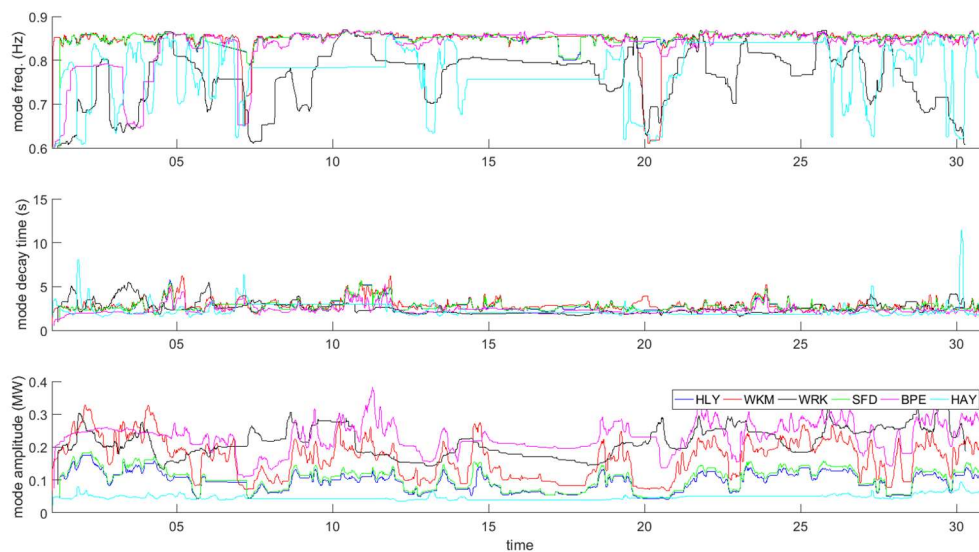


Figure 18: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Modes ~0.65, ~0.8, and ~0.85 Hz observed.
- All modes well damped.

Using active power:

- Modes 0.6-0.65 Hz, 0.7 Hz, 0.8 Hz, and 0.85 Hz observed.
- Decay time typically between 2-5 seconds for all modes, once increasing to 10 seconds at Haywards.
- Maximum oscillation amplitude ~400 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

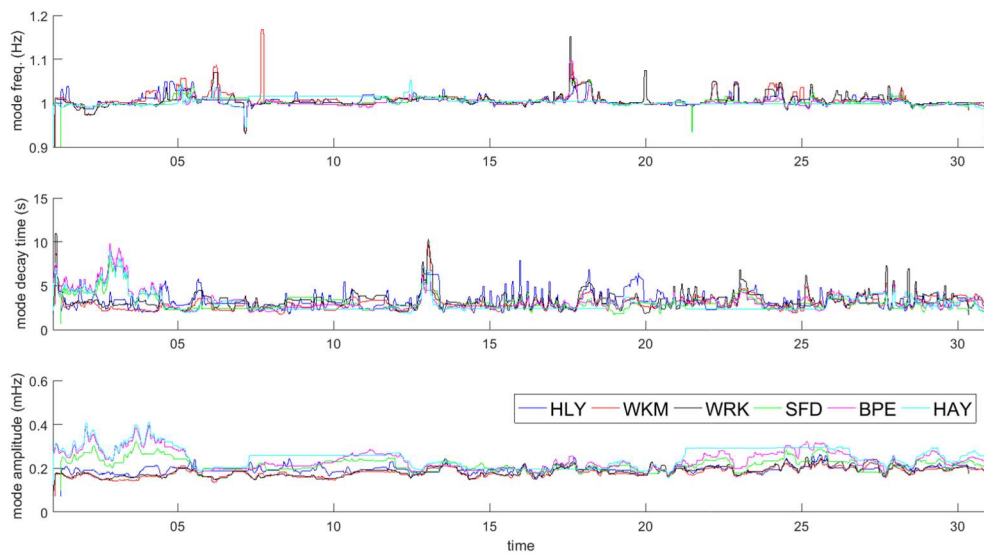


Figure 19: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

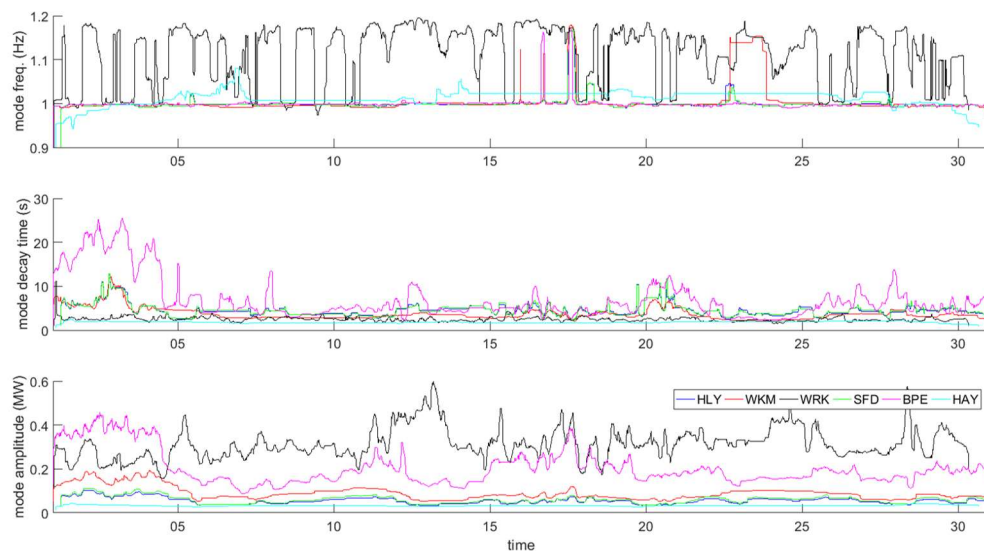


Figure 20: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes at 1.0 Hz, 1.05 Hz and ~1.18 Hz.
- Most modes decay time between 5-10 seconds.

Using active power:

- Distinct modes at 1.0 Hz and ~1.18 Hz.
- Most mode decay times are between 5-10 seconds, increasing to 25 seconds for the 1 Hz mode at Bunnythorpe at the start of the month.
- Maximum oscillation amplitude ~600 kW for 1.18Hz at WRK.

3.7 Mode band 5: [1.2 - 1.8 Hz]

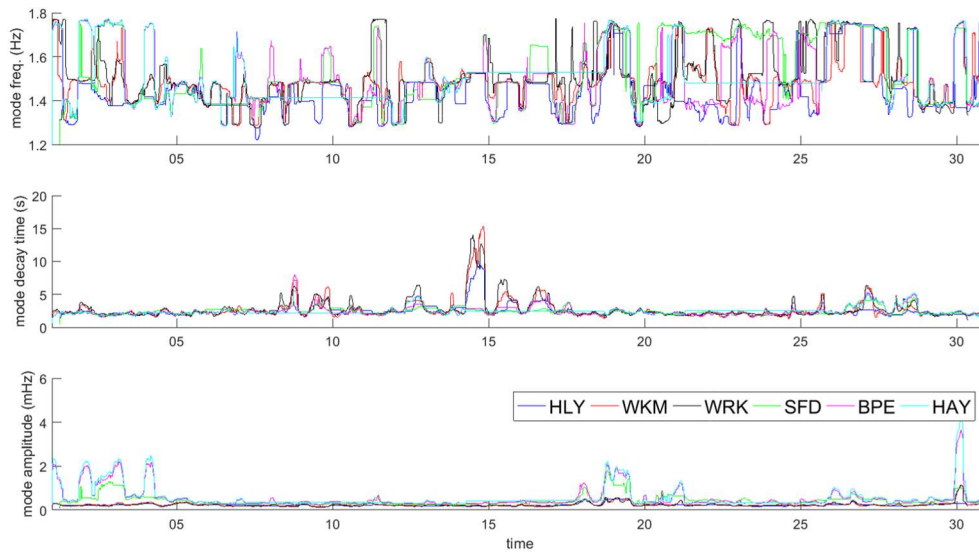


Figure 21: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

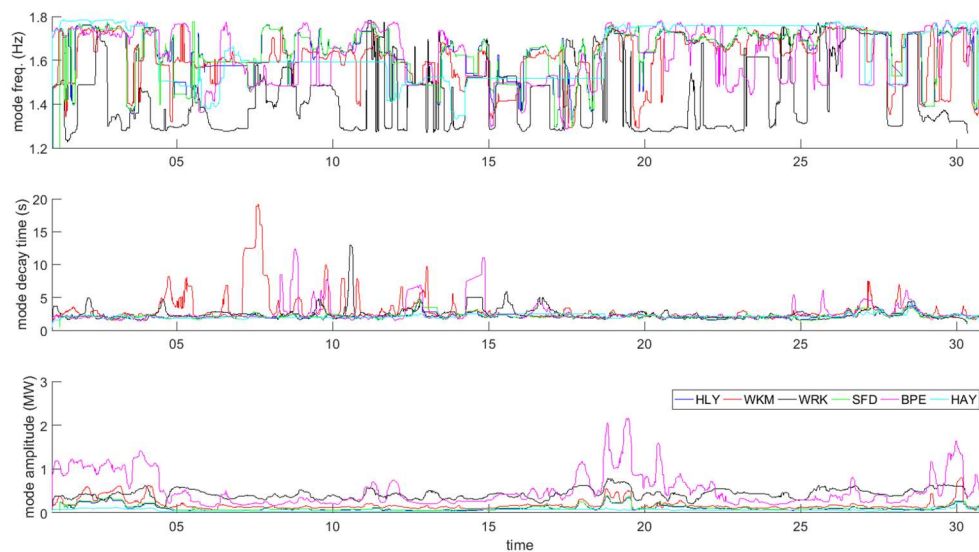


Figure 22: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes around ~1.3 Hz, 1.4, 1.5 Hz, and 1.8 Hz.
- Most mode decay times around 3-5 seconds with an increase once to 15 seconds near 15th November.

Using active power:

- Distinct modes around ~1.3 Hz, 1.5 Hz, and 1.6-1.8 Hz.
- Decay time below 15 seconds for all modes with one increase to 20 seconds at Whakamaru.

- Maximum oscillation amplitude around 2 MW at Bunnythorpe near 20th November, however this is well damped.

3.8 Mode band 6: [1.8 – 2.4 Hz]

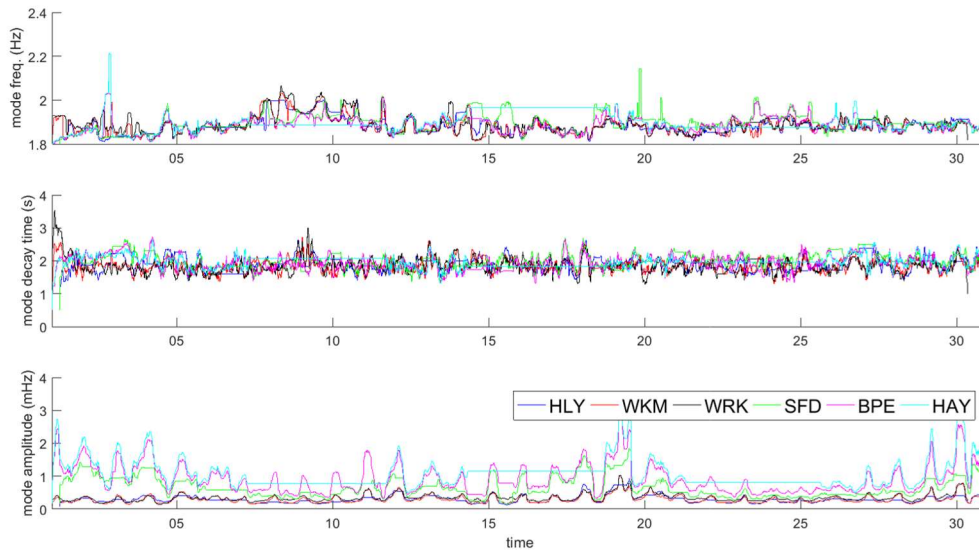


Figure 23: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

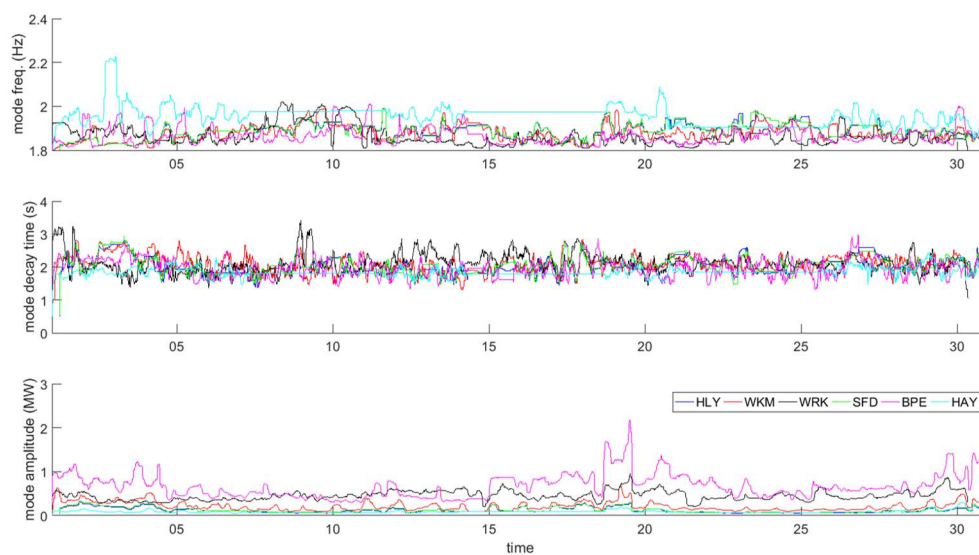


Figure 24: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes 1.8-2.0 Hz, and 2.2 Hz observed.
- All modes in this band are relatively well-damped.

Using active power:

- Maximum oscillation amplitude ~2 MW reported at Bunnythorpe. However, all modes are well damped.

3.9 Mode band 7: [2.4 – 4 Hz]

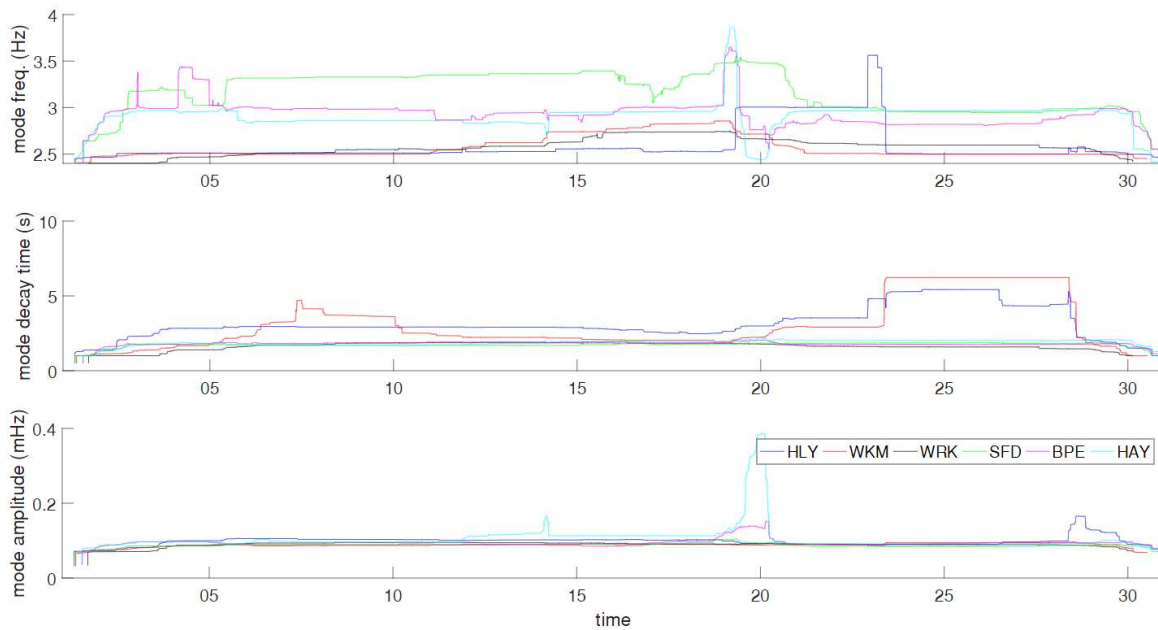


Figure 25: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

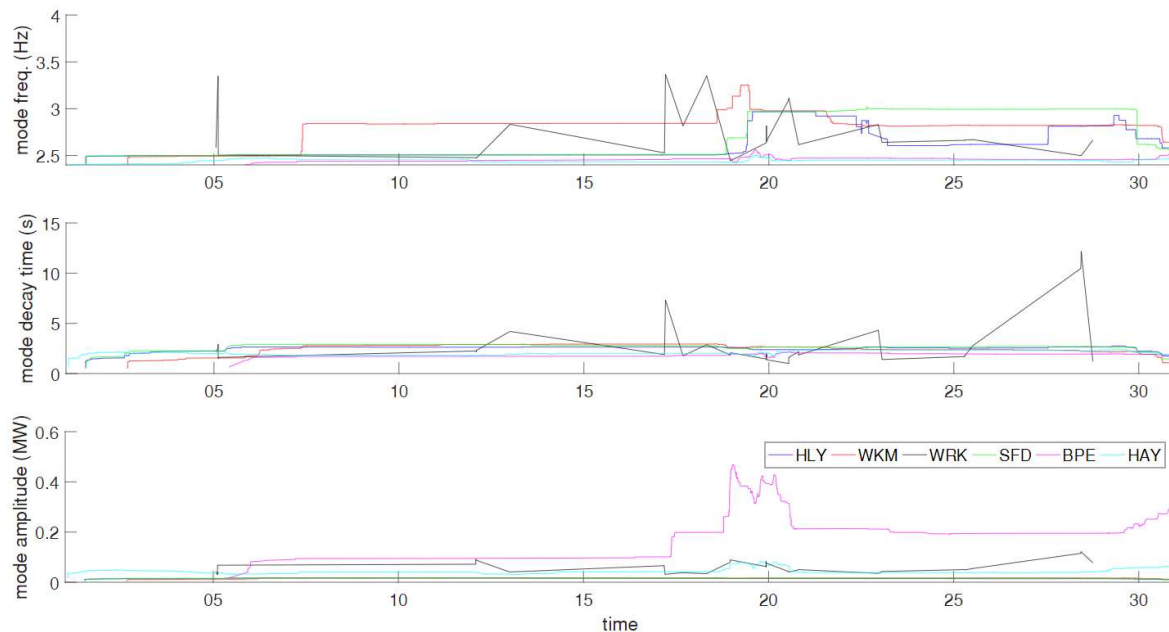


Figure 26: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Modes observed at 2.5 Hz, ~2.7 Hz, 3 Hz and 3.25 Hz.
- All modes in this band are relatively well-damped. Note that isolated outlying data points with long decay time in the histograms are often not visible in the trends due to the moving average approach used to draw the trend

Using active power:

- Maximum oscillation amplitude for this mode band is 400kW, visible at Bunnythorpe. Again outliers from the histogram are not visible in the trend.