

DYNAMIC STABILITY MONTHLY REPORT

NORTH ISLAND – MAY 2022

Transpower New Zealand Limited

May 2022

Keeping the energy flowing



TRANSPOWER



NOTICE**COPYRIGHT © 2022 TRANSPOWER New Zealand LIMITED****ALL RIGHTS RESERVED**

The information contained in the report is protected by copyright vested in Transpower New Zealand Limited ("Transpower"). The report is supplied in confidence to you solely for your information. No part of the report may be reproduced or transmitted in any form by any means including, without limitation, electronic, photocopying, recording, or otherwise, without the prior written permission of Transpower. No information embodied in the report which is not already in the public domain shall be communicated in any manner whatsoever to any third party without the prior written consent of Transpower.

Any breach of the above obligations may be restrained by legal proceedings seeking remedies including injunctions, damages and costs.

LIMITATION OF LIABILITY/DISCLAIMER OF WARRANTY

Transpower make no representation or warranties with respect to the accuracy or completeness of the information contained in the report. Unless it is not lawfully permitted to do so, Transpower specifically disclaims any implied warranties of merchantability or fitness for any particular purpose and shall in no event be liable for, any loss of profit or any other commercial damage, including but not limited to special, incidental, consequential or other damages.

Version	Date	Change
1.0	26/02/2024	Final
	Position	Date
Prepared By:	Richard Sherry, Principal Engineer	26/02/2024
Reviewed By:		

Contents

1	Executive summary	4
1.1	Purpose.....	4
1.2	Objectives	4
2	Current status and observations	4
3	Detailed plots for May 2022	5
3.1	Mode frequency histograms	5
3.1.1	PMU Frequency Data.....	5
3.1.2	PMU Active Power Data.....	8
3.1.3	Observations using the frequency histograms.....	11
3.2	Defining mode bands	11
3.3	Mode band 1: [0.0 – 0.2 Hz]	12
3.4	Mode band 2: [0.2 – 0.6 Hz]	13
3.5	Mode band 3: [0.6 – 0.9 Hz]	14
3.6	Mode band 4: [0.9 – 1.2 Hz]	15
3.7	Mode band 5: [1.2 - 1.8 Hz].....	16
3.8	Mode band 6: [1.8 – 2.4 Hz]	17

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 May 2022. This monthly report presents these findings for May 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.)

Unfortunately the Wairakei PMU was disabled during works on site and no data is available for Wairakei this month

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 May 2022
0.04 Hz	All-f	Governor modes	No significant change over the month
0.25 Hz	All-f Most-p	Probably control modes, and not electro-mechanical	Relatively high number of occurrences Some periods of low damping
0.5 – 0.6 Hz	All-f Most-p	Possibly Inter area modes	Typically well damped
~ 1.0 Hz	All-f Most-p	Local and Inter-station modes	Occasional poor damping but at low magnitudes
1.7-1.9 Hz	All-f All-p	Inter-station and Local modes	High number of occurrences, particularly around BPE

3 Detailed plots for May 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

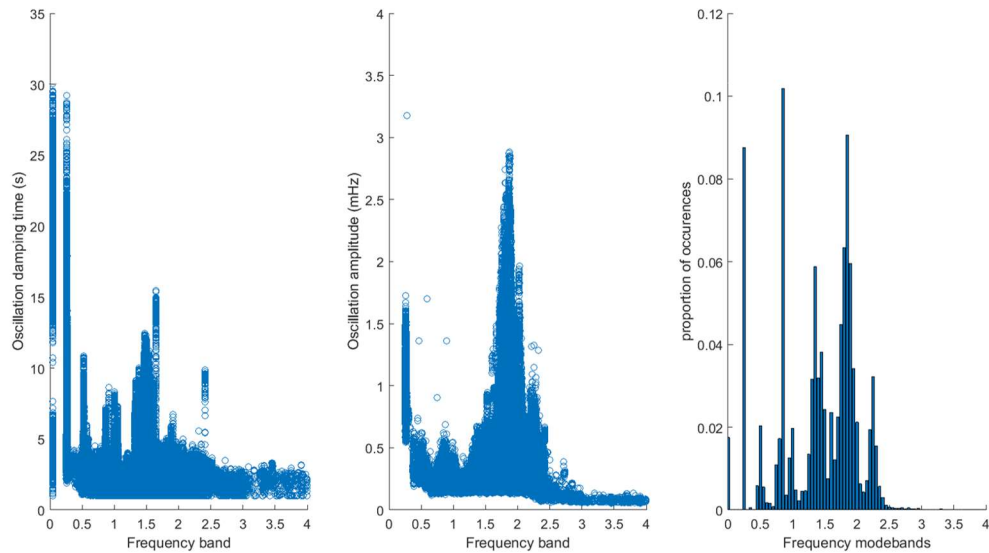


Figure 1: Bunnythorpe mode damping, mode amplitude, and frequency histogram using frequency data

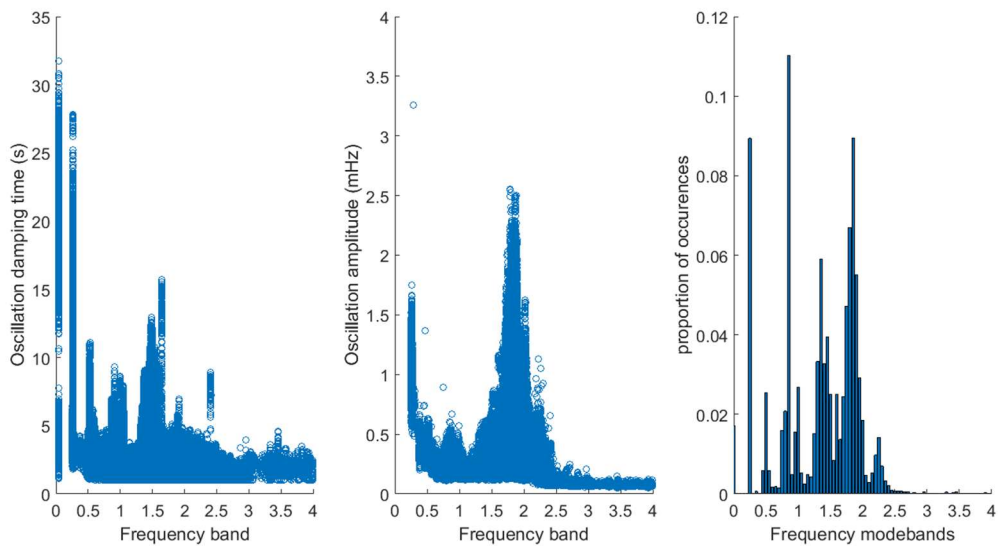


Figure 2: Haywards mode damping, mode amplitude, and frequency histogram using frequency data

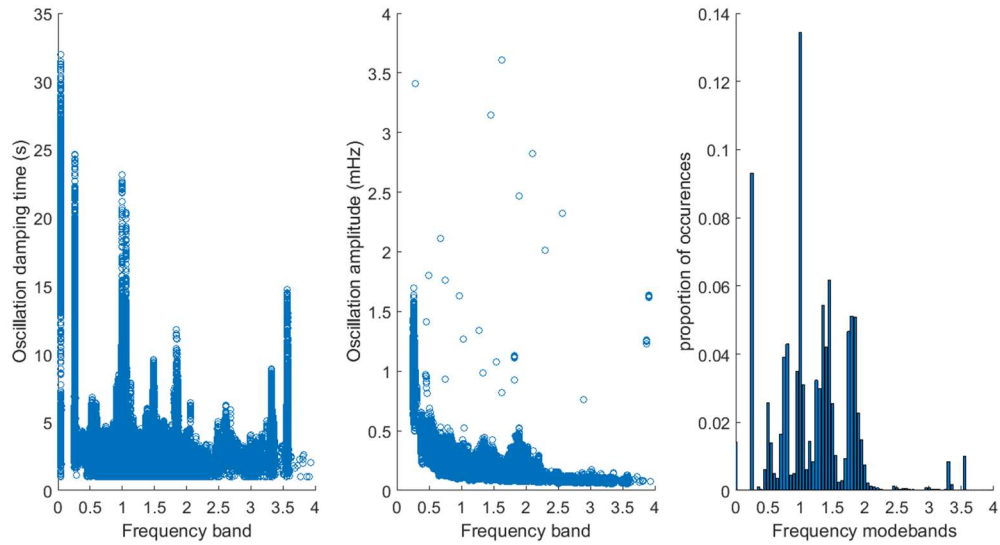


Figure 3: Huntly mode damping, mode amplitude, and frequency histogram using frequency data

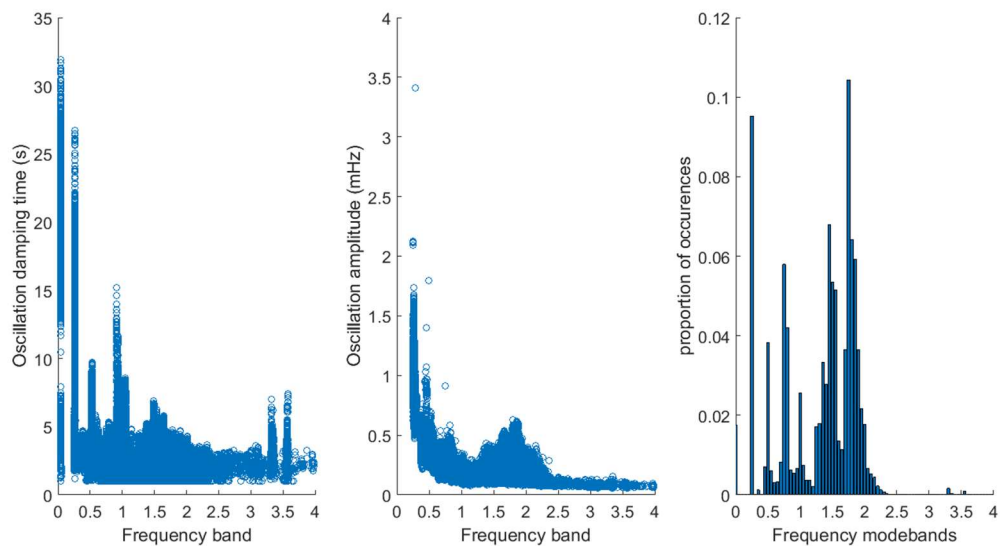


Figure 4: Stratford mode damping, mode amplitude, and frequency histogram using frequency data

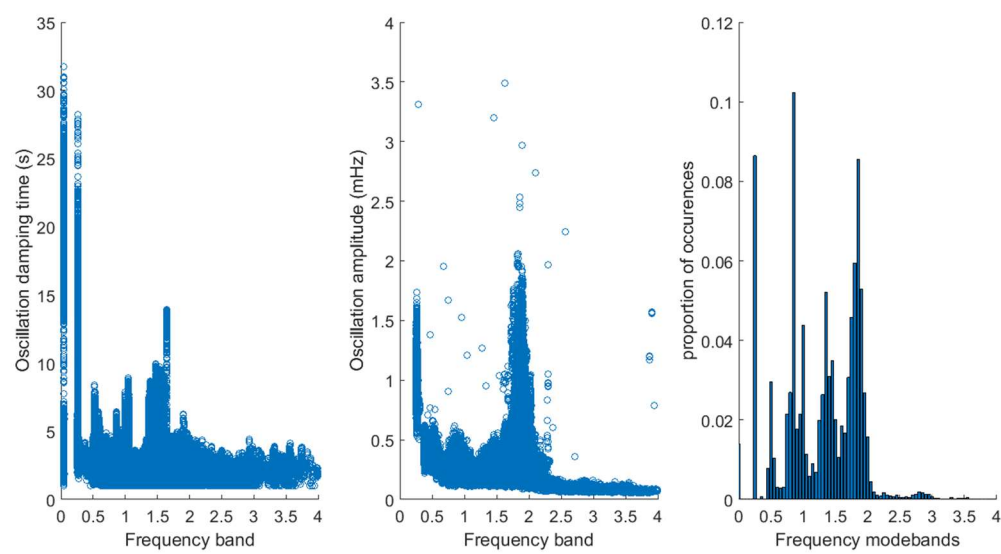


Figure 5: Whakamaru mode damping, mode amplitude, and frequency histogram using frequency data

3.1.2 PMU Active Power Data

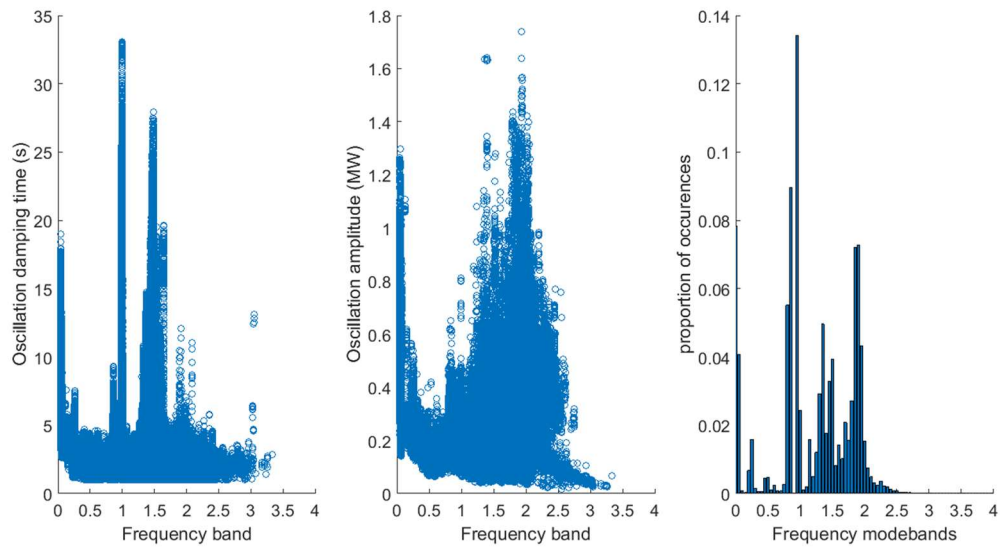


Figure 6: Bunnythorpe mode damping, mode amplitude, and frequency histogram, active power data

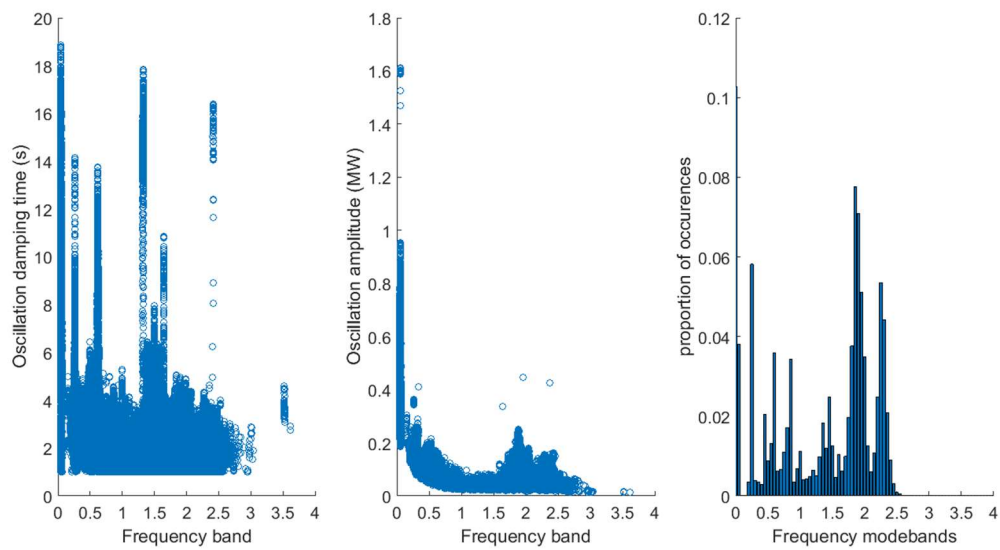


Figure 7: Haywards mode damping, mode amplitude, and frequency histogram using active power data

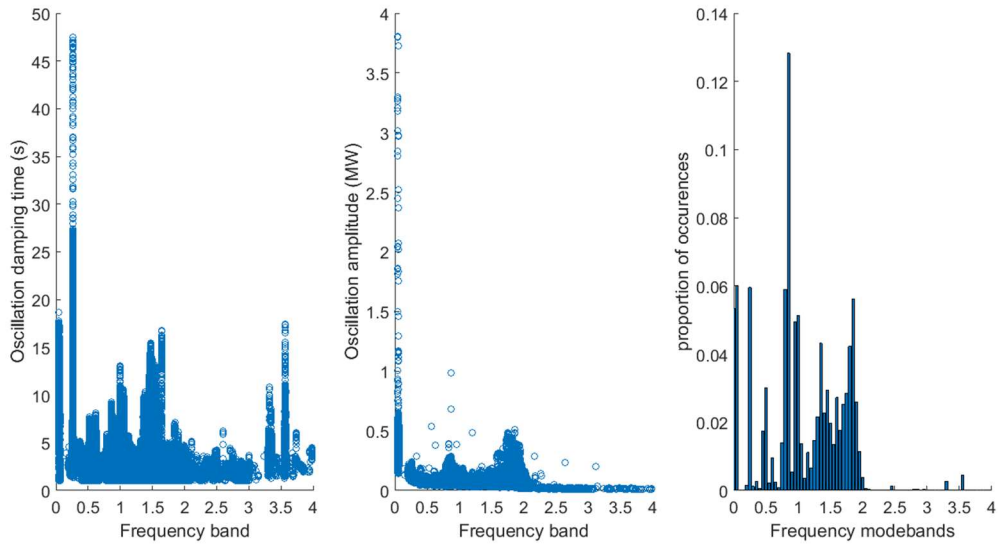


Figure 8: Huntly mode damping, mode amplitude, and frequency histogram using active power data

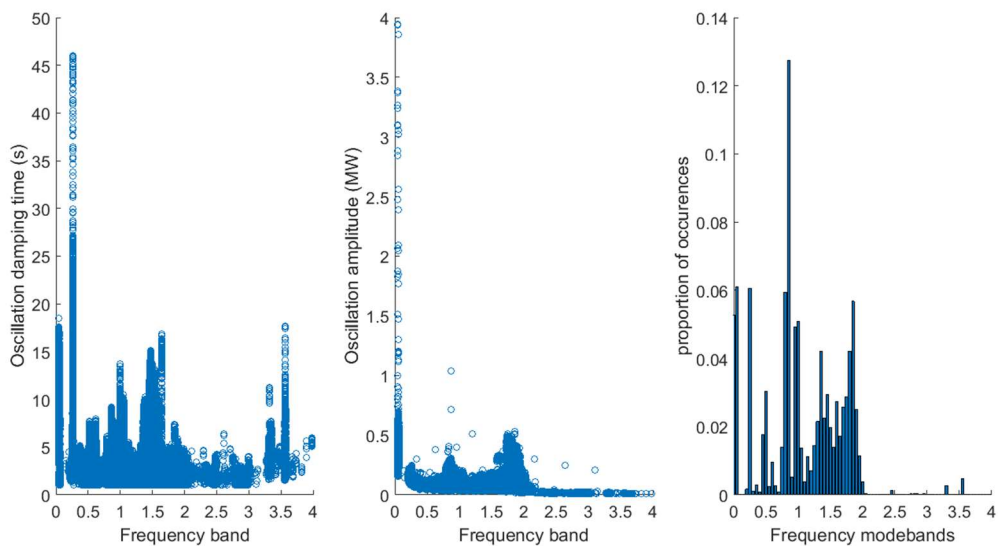


Figure 9: Stratford mode damping, mode amplitude, and frequency histogram using active power data

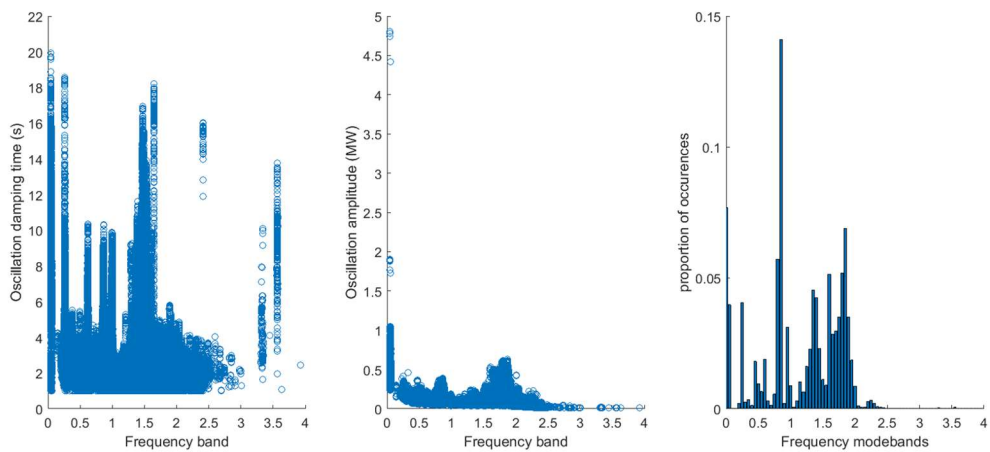


Figure 10: Whakamaru mode damping, mode amplitude, and frequency histogram using active power data

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 May data. An additional mode observed in this months data is 1.0 Hz with high oscillation damping time however it is not a concern at the magnitudes observed.

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

1.35 Hz

1.8 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]

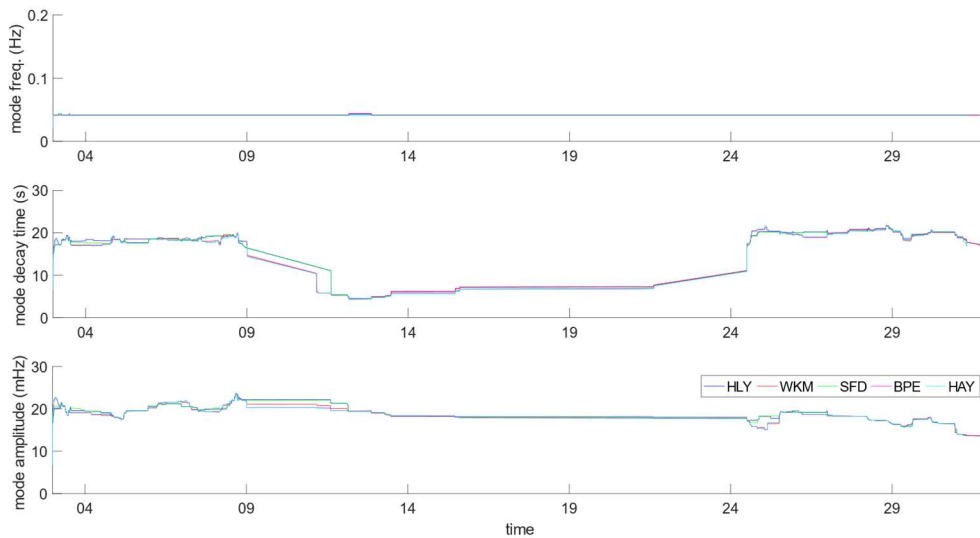


Figure 11: PhasorPoint results for the modeband [0.0 0.2 Hz] using PMU frequency data

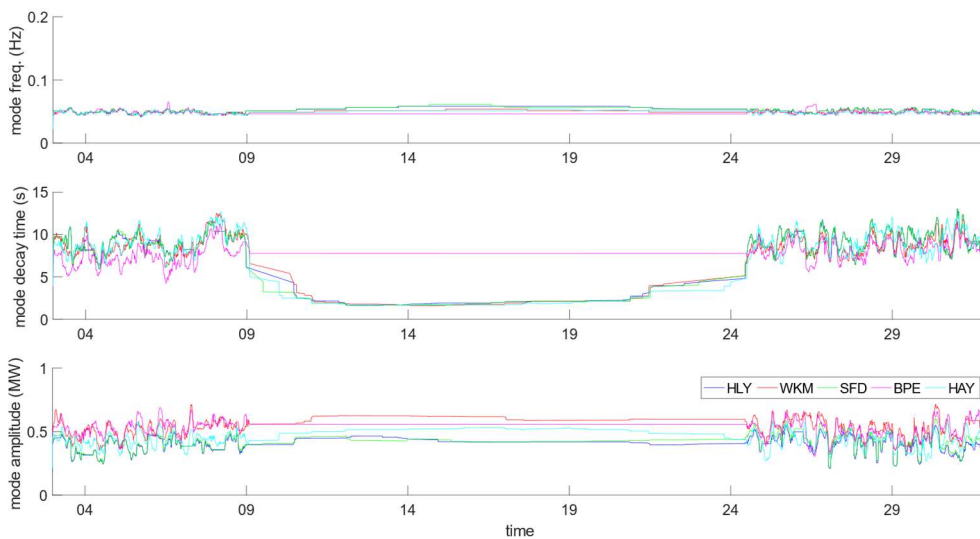


Figure 12: PhasorPoint results for the modeband [0.0, 0.2 Hz] using PMU active power data

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 only around 20 mHz.

Using active power:

- 0.04 Hz mode at all substations.
- Maximum oscillation amplitude ~600 kW.

3.4 Mode band 2: [0.2 – 0.6 Hz]

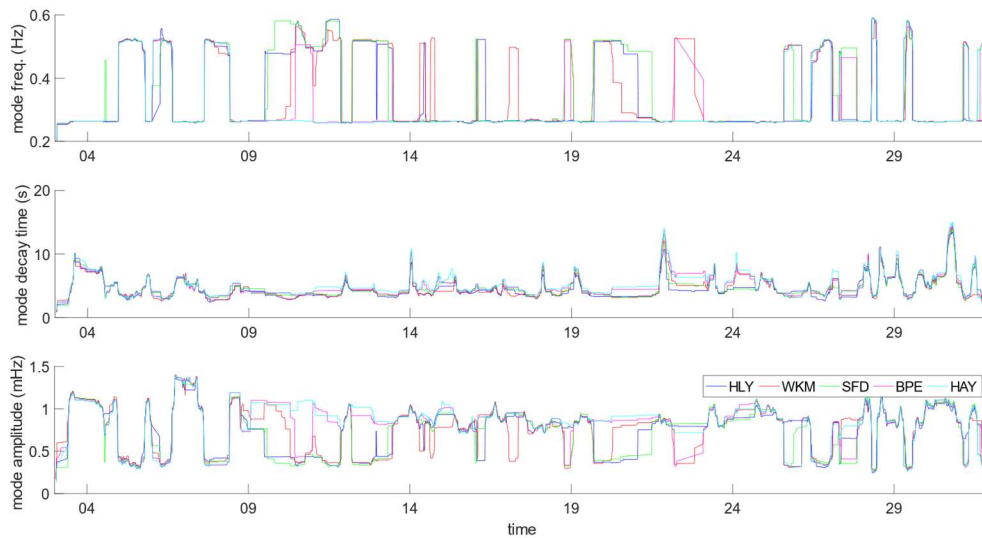


Figure 13: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU frequency data

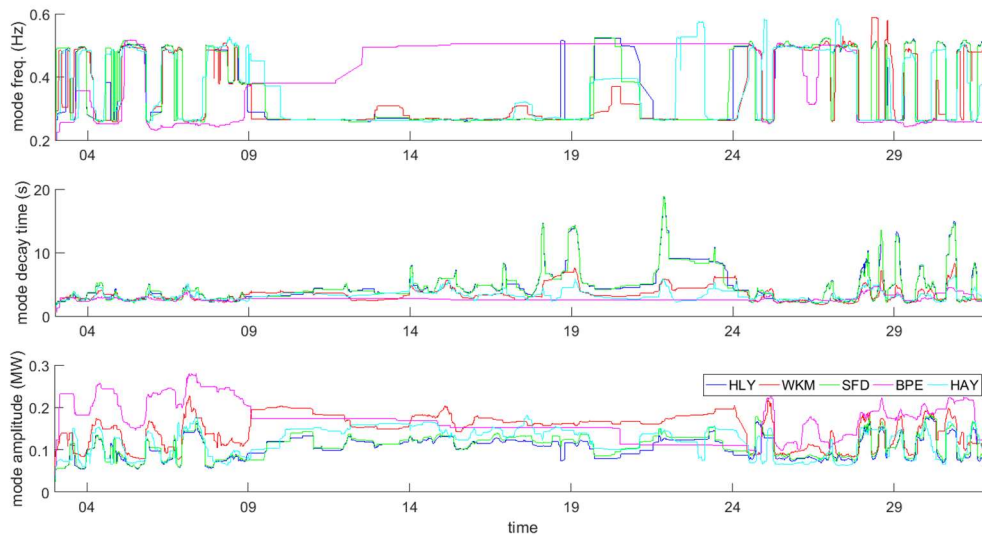


Figure 14: PhasorPoint results for the modeband [0.2, 0.6 Hz] using PMU active power data.

Using PMU frequency

- 0.25 Hz and 0.5 Hz modes observed at all stations. Decay time around 5-10 seconds. Likely both modes are persistent, the report shows the larger

Using active power:

- 0.25 Hz modes observed at all stations, 0.5 Hz mode observed at most stations from time to time. Again both modes are probably persistent.
- Decay time around 5-10 seconds, increasing to 20 seconds at certain periods.
- Maximum oscillation amplitude ~250 kW.

3.5 Mode band 3: [0.6 – 0.9 Hz]

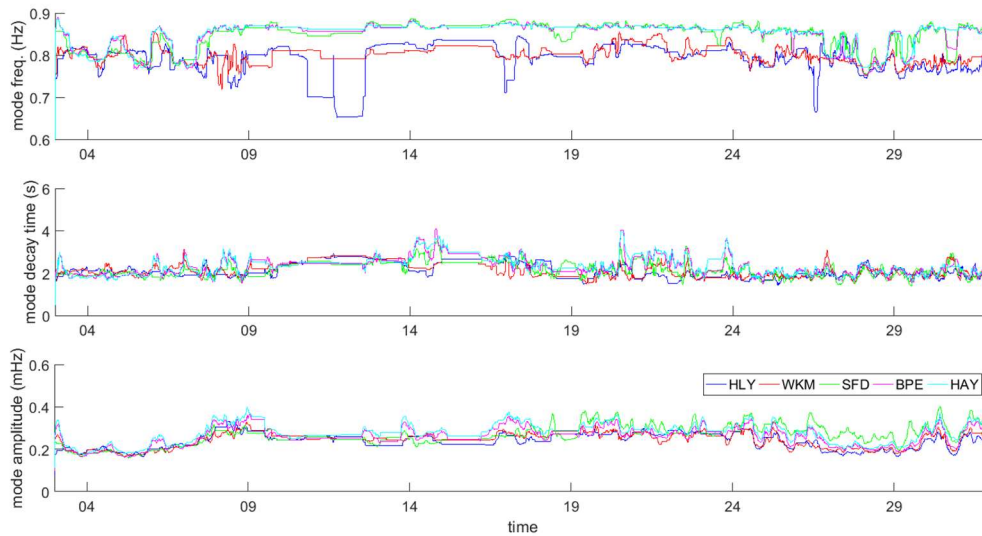


Figure 15: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU frequency data

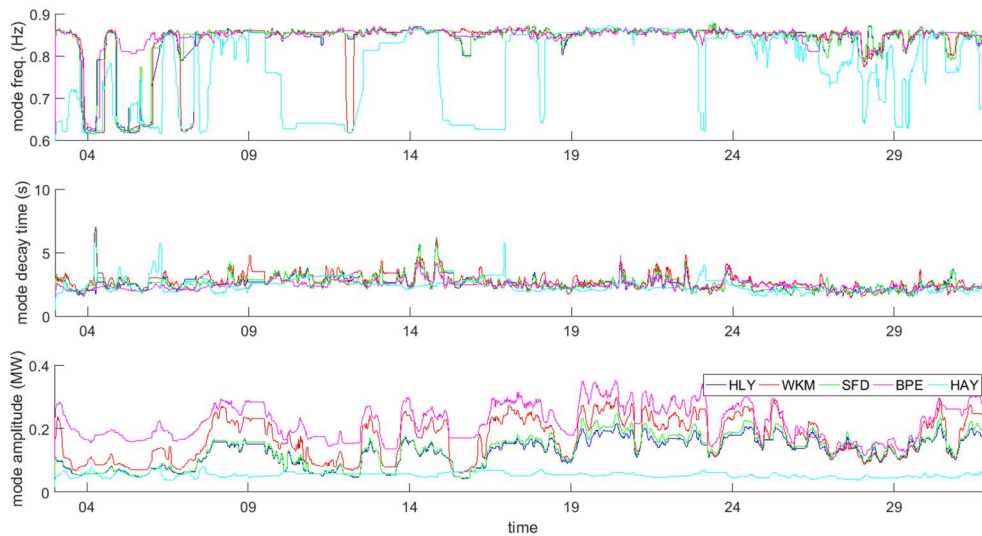


Figure 16: PhasorPoint results for the modeband [0.6, 0.9 Hz] using PMU active power data

Using PMU frequency:

- Modes 0.65, 0.8, and ~0.9 Hz observed.
- Decay time typically between 2-4 seconds.

Using active power

- Distinct modes 0.65 Hz, and 0.85 Hz observed.
- Decay time typically between 2-5 seconds at most sites.
- Maximum oscillation amplitude ~300 kW.

3.6 Mode band 4: [0.9 – 1.2 Hz]

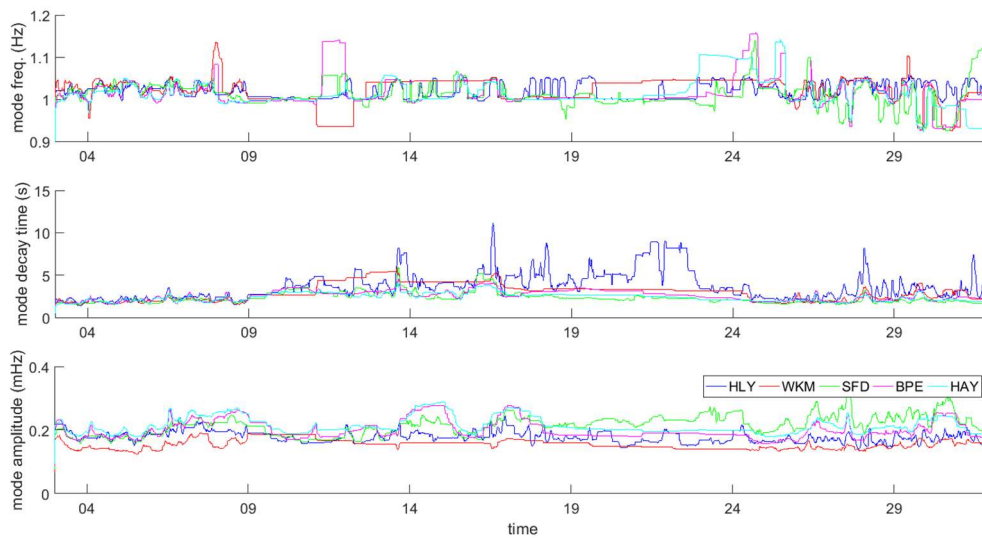


Figure 17: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU frequency data

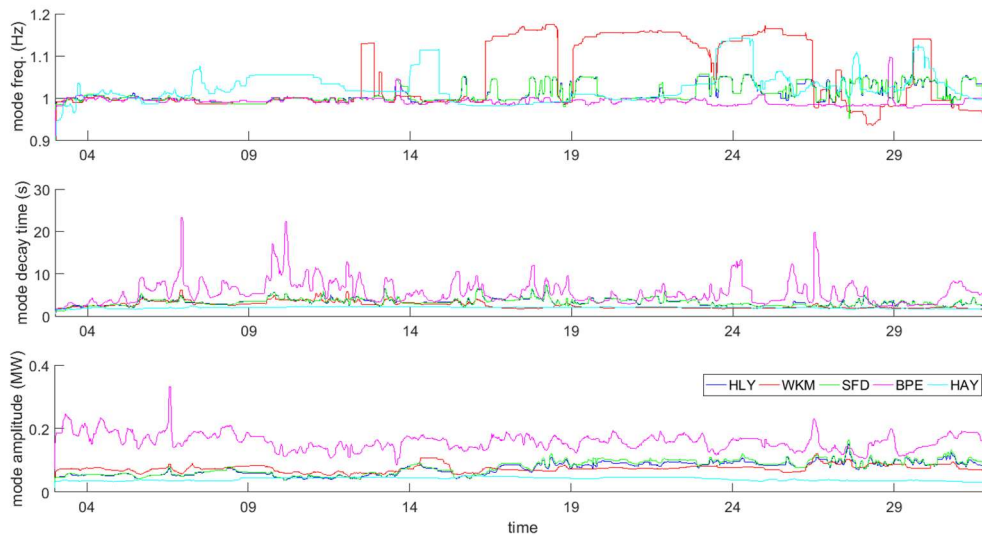


Figure 18: PhasorPoint results for the modeband [0.9, 1.2 Hz] using PMU active power data

Using PMU frequency:

- Distinct modes observed 0.95 Hz, 1.0 Hz, and 1.05 Hz
- Most modes decay time between 2-5 seconds.

Using active power

- Most modes are typically well damped except 1.0 Hz exhibited a relatively high decay time around 20 seconds at BPE at certain periods.
- Maximum oscillation amplitude ~200 kW again at BPE.

3.7 Mode band 5: [1.2 - 1.8 Hz]

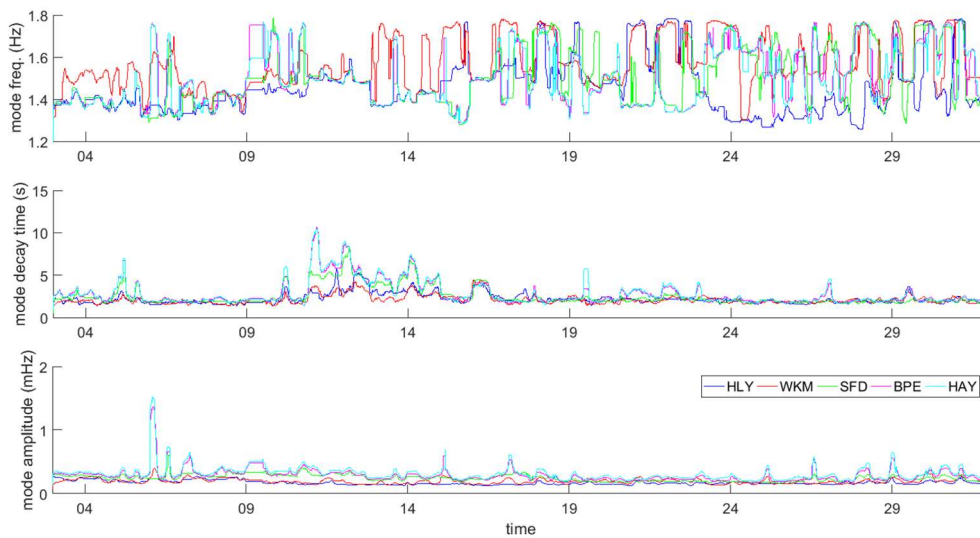


Figure 19: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU frequency data

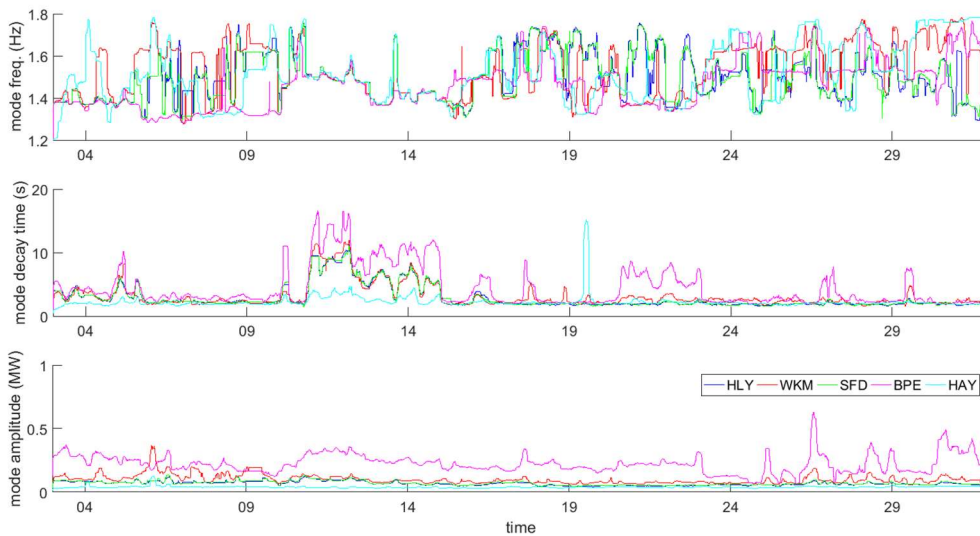


Figure 20: PhasorPoint results for the modeband [1.2, 1.8 Hz] using PMU active power data

Using PMU frequency:

- Modes reported across the band e.g. ~1.35 Hz, 1.4, 1.5 Hz, and 1.8 Hz
- Most modes decay time is around 2 seconds increasing to 10 seconds for individual modes.

Using active power:

- Modes reported across the band e.g. ~1.35 Hz, 1.5 Hz, 1.6, and 1.8 Hz
- Decay time around 2 seconds for all modes increasing up to 15 seconds for individual modes, notably 1.4/1.5 Hz at BPE around 11th May.
- Maximum oscillation amplitude around 0.3 MW.

3.8 Mode band 6: [1.8 – 2.4 Hz]

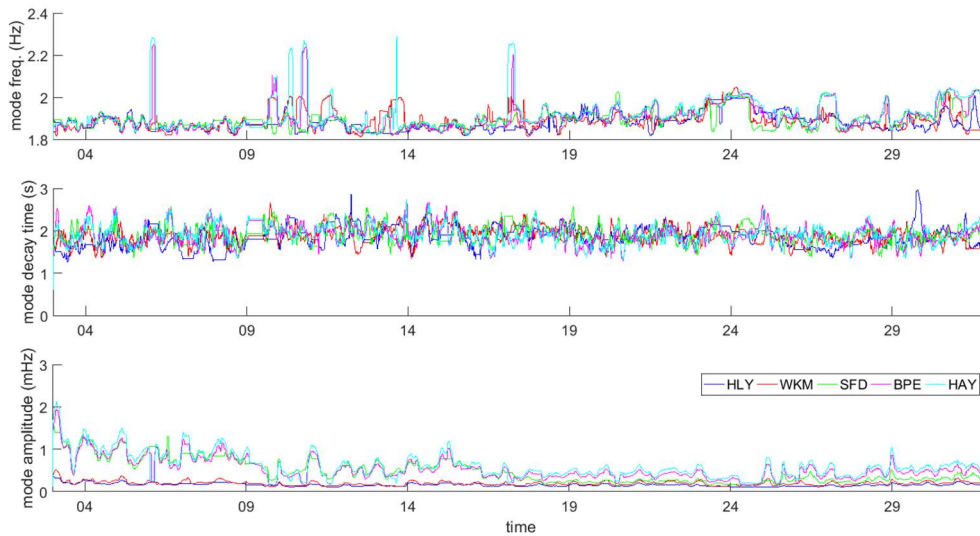


Figure 21: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU frequency data

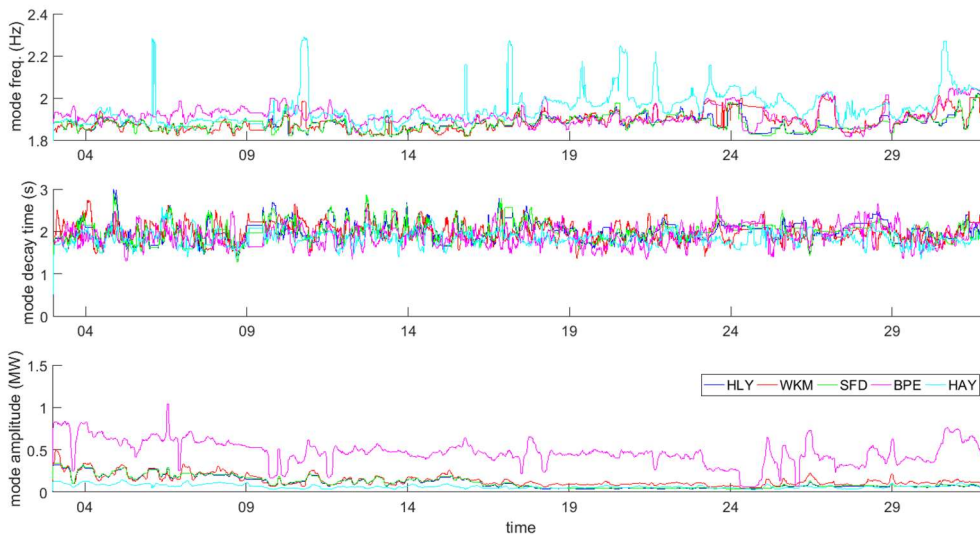


Figure 22: PhasorPoint results for the modeband [1.8, 2.4 Hz] using PMU active power data

Using PMU frequency:

- Modes 1.9 Hz to 2.0 Hz mostly, briefly 2.2 Hz observed.
- All modes in this band are relatively well-damped.

Using active power:

- Modes around 1.9 Hz with some 2.2 Hz at HAY
- Maximum oscillation amplitude ~0.7 MW predominantly at Bunnythorpe.

3.9 Mode band 7: [2.4 – 4 Hz]

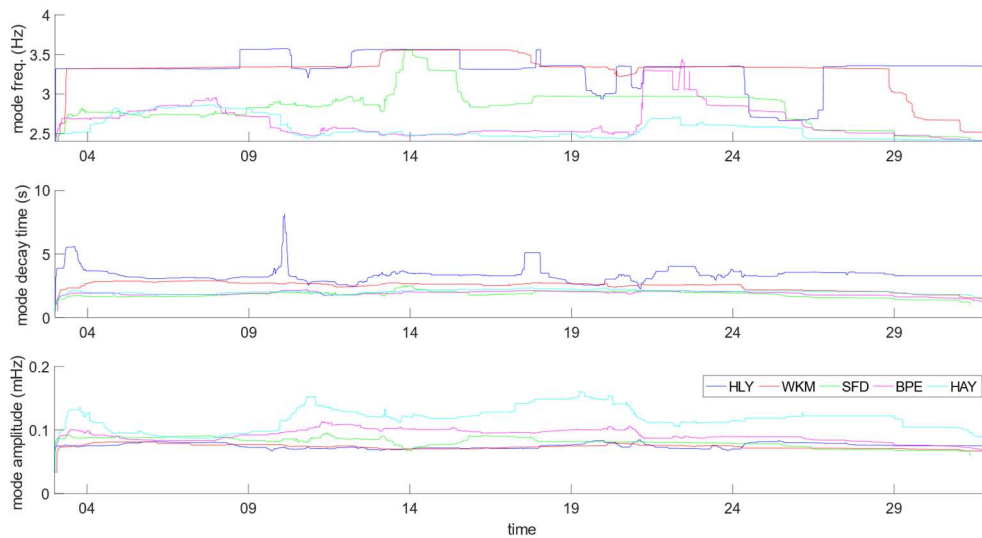


Figure 23: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU frequency data

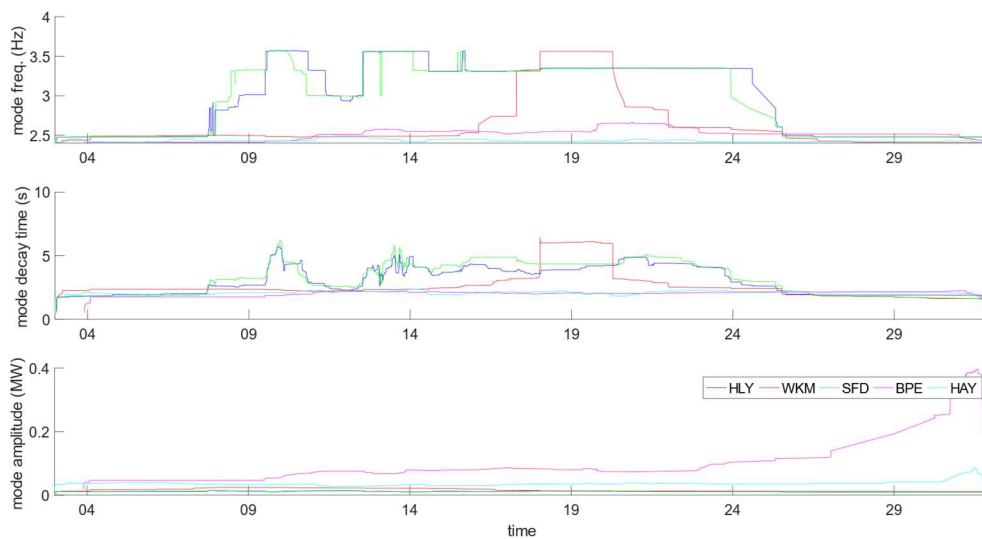


Figure 24: PhasorPoint results for the modeband [2.4, 4 Hz] using PMU active power data

Using PMU frequency:

- Modes at 2.5 and 3.5 Hz observed at most sites, with SFD in between.
- All modes in this band are low magnitude and well-damped.

Using active power:

- Modes at 2.5, 3.0 (SFD and HLY) and 3.5 Hz observed
- Maximum oscillation amplitude usually <0.1 MW indicates the observations are borderline noise, exception being BPE reaching 0.4 MW at 2.5 Hz late in the month