Phasor Measurements Recording in Iceland
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Background: The Icelandic power system is based on a 132 kV ring around the island, see Figure 1. The load center is located in the southwest, around Reykjavik, and the main generation area is in the mid-south around Sigalda. However, two major plants are located in the north part; Blanda (150 MW) and Krafla (60 MW).

Figure 1. The Island power system, equipped with PMUs.

During high load conditions the power flow in the ring is from the north to the south. If a fault occurs (most frequently on the west side), the ring is split and all the power has to go through the eastern part. Rather heavy, poorly damped, oscillations, might occur. To be able to find out if voltage phase-angles in different parts of the system are suitable inputs to a damping equipment, PMUs have been installed in two critical nodes (the Krafla PMU is not yet commissioned) and recordings can be made. The table in Appendix 1 shows the quantities recorded. The GPS time synchronizing signal is used as a reference for the voltage phase angle. Voltages, active and reactive power flow, and the system frequency are recorded. Based on the voltage real and imaginary part, the magnitude and the phase-angle can be derived. All measurements are three-phase and the recorded voltage is the positive sequence voltage.

Field tests: February 27, in the afternoon, the 132 kV line Krafla-Rangárvellir was taken into operation after maintenance work. The logging process was set up in Norway, and data transfer was made via ISDN-modem. The SCADA snapshots before and after the switching are shown in Appendix 2 (The switched line, KR1, is to the upper right in the diagram.

Results: The results from this cautious test (the power flow after switch-in of the line was just 5 MW) are shown in the diagrams in Appendix 3. The diagrams shows the data as they appear from the log-files, no filtering has been done. It is impressing to see the high resolution and the distinct signals. The magnitude of the oscillations is limited as well as the duration. The frequency of the oscillation is around 1 Hz. It is especially interesting to compare the voltage phase-angle between Blanda and Sigalda, and the total output active power from the Blanda power station. The correlation is, as expected, obvious.

Conclusions: The recordings are very promising. The theory for power system damping based on phasor measurements is known and established [1]. The present recording shows that the ABB PMUs provide high resolution, noise free signals suitable as inputs for power oscillation damping equipment.

Future work: It is important for the success of the project that the logging on site in Sigalda will be established very soon, to provide continuous logging, to be able to catch spontaneous as well as planned events.

Acknowledgements: The recording made by Arve Sollie, is gratefully acknowledged, as well as the PMU-setup work performed both in Sweden and in Iceland, by Thórhallur Hrafnsson and Johan Sälj.

Reference

[1] Samuelsson, O. and Eliasson, B., "Damping of Electro-Mechanical Oscillations in a Multimachine System by Direct Load Control", *IEEE Transactions on Power Systems*, Vol. 12, No. 4, pp. 1604-1609, 1997.

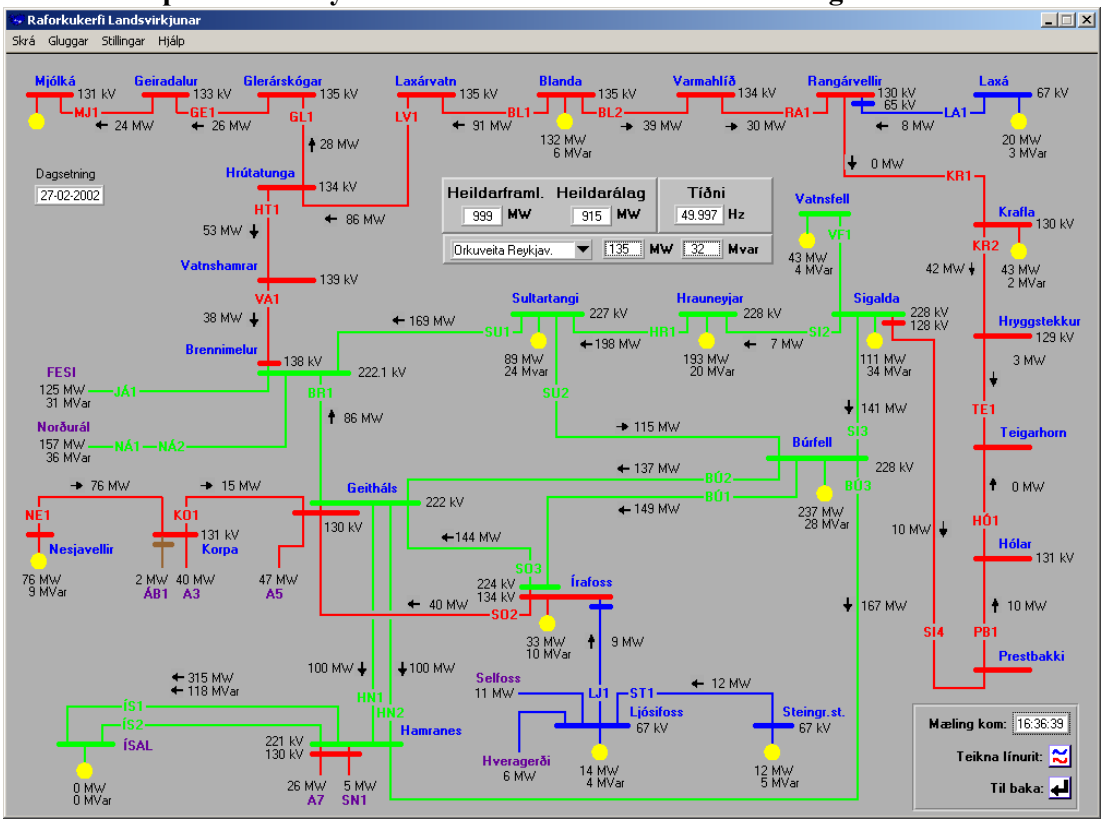
Appendix 1

Power System Quantities Recorded by the PMUs in Blanda and Sigalda

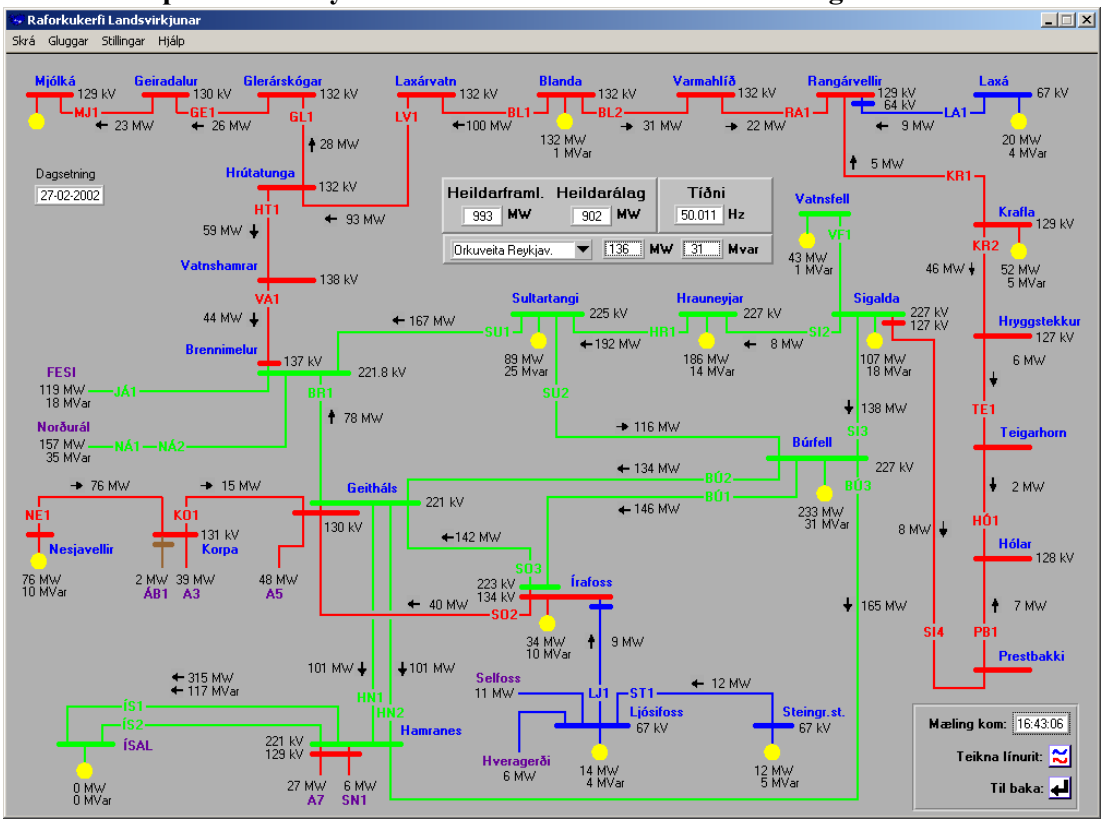
Voltage Sigalda 130 kV real part, positive sequence, [kV]
Voltage Sigalda 130 kV imaginary part, positive sequence, [kV]
Voltage Sigalda 220 kV real part, positive sequence, [kV]
Voltage Sigalda 220 kV imaginary part, positive sequence, [kV]
Voltage Blanda 130 kV real part, positive sequence, [kV]
Voltage Blanda 130 kV imaginary part, positive sequence, [kV]
Voltage Blanda Unit 1 real part, positive sequence, [kV]
Voltage Blanda Unit 1 imaginary part, positive sequence, [kV]
Active Power Sigalda-Prestbakki [MW]
Reactive Power Sigalda-Prestbakki [Mvar]
Active Power Sigalda Trafo 220/132 [MW]
Reactive Power Sigalda Trafo 220/132 [Mvar]
Active Power Sigalda Trafo Unit 1 [MW]
Reactive Power Sigalda Trafo Unit 1 [Mvar]
Active Power Blanda-Laxárvatn [MW]
Reactive Power Blanda-Laxárvatn [Mvar]
Active Power Blanda-Varmahlið [MW]
Reactive Power Blanda-Varmahlið [Mvar]
Active Power Blanda Trafo Unit 1 [MW]
Reactive Power Blanda Trafo Unit 1 [Mvar]
Active Power Blanda Unit 1 [MW]
Reactive Power Blanda Unit 1 [Mvar]
Frequency [Hz]

Appendix 2

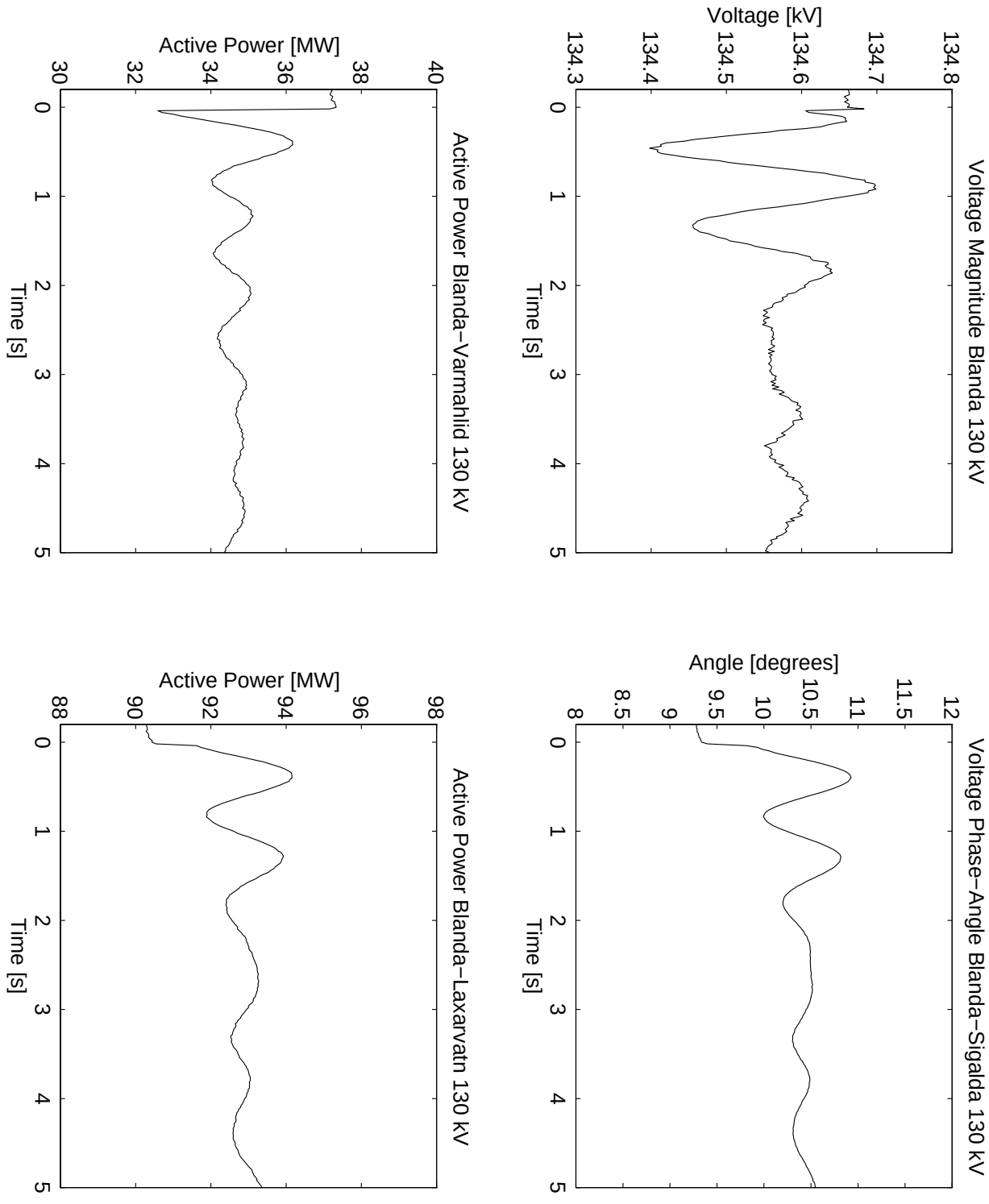
SCADA Snapshot – steady state conditions – before the switching

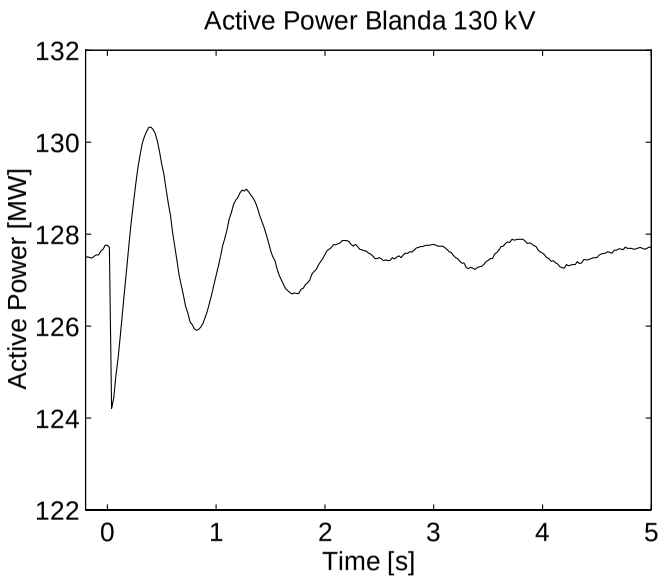


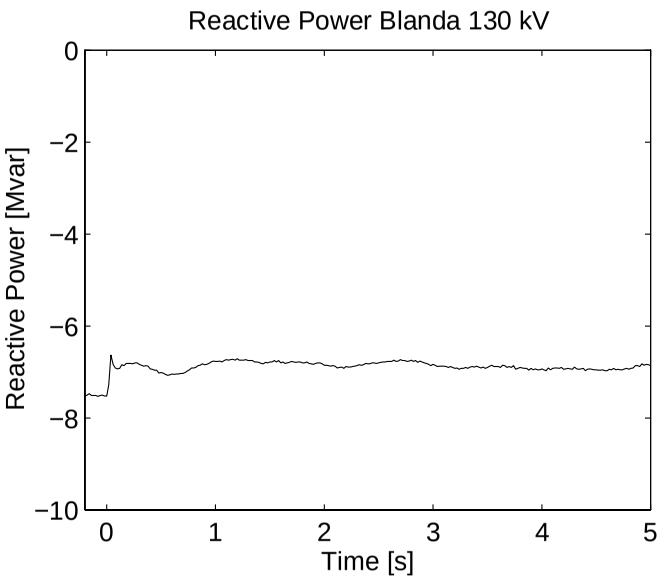
SCADA Snapshot – steady state conditions – before the switching

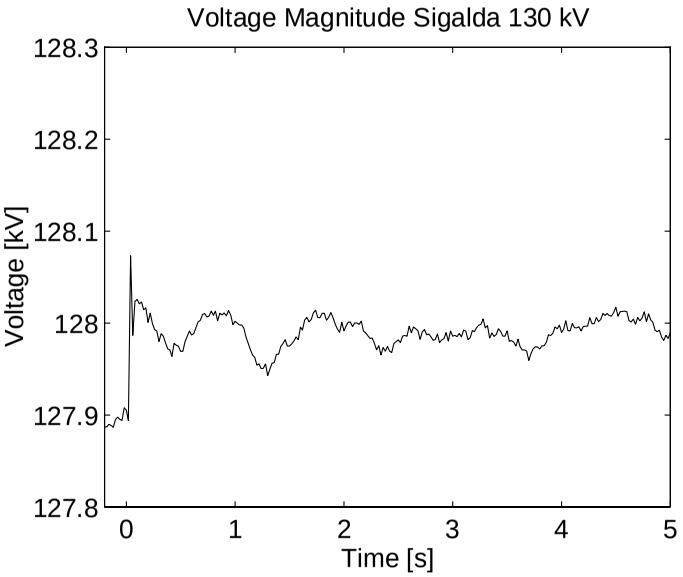


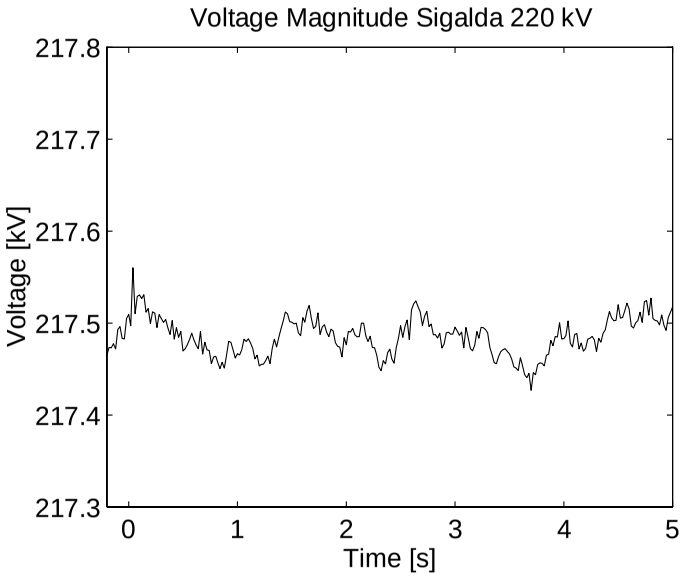
Recordings from the PMUs in Blanda and Sigalda – 2002-02-27




Active Power Blanda 130 kV
Active Power [MW]
Time [s]
132
130
128
126
124
122
0
1
2
3
4
5


Reactive Power Blanda 130 kV
Reactive Power [Mvar]
Time [s]
0
−2
−4
−6
−8
−10
0
1
2
3
4
5


Voltage Magnitude Sigalda 130 kV
Voltage [kV]
Time [s]
128.3
128.2
128.1
128
127.9
127.8
0
1
2
3
4
5


Voltage Magnitude Sigalda 220 kV
Voltage [kV]
Time [s]
217.8
217.7
217.6
217.5
217.4
217.3
0
1
2
3
4
5