Study Committee C4

Power System Technical Performance C4

10814_2022

Assessment of the impact of simulation model complexity on frequency stability studies – case Nordic power system

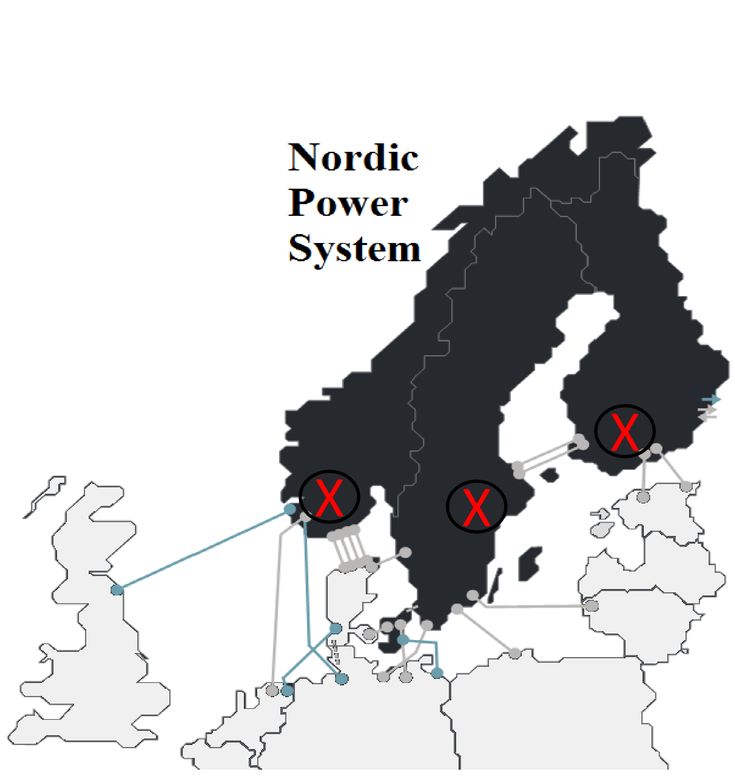
Niklas Modig (Svenska kraftnät)
Robert Eriksson (Svenska kraftnät)
Mikko Kuivaniemi (Fingrid)

Approach

- Comparing full scale RMS and simplified model → Frequency minimum and damping
- Varying dynamics of load and power system stabilizers in the RMS model

Motivation

- Using a simplified model will provide several benefits
  - Implementation in the control room
  - Shorter computation time
- Simplified model must be validated in order to ensure reliability



ΔP

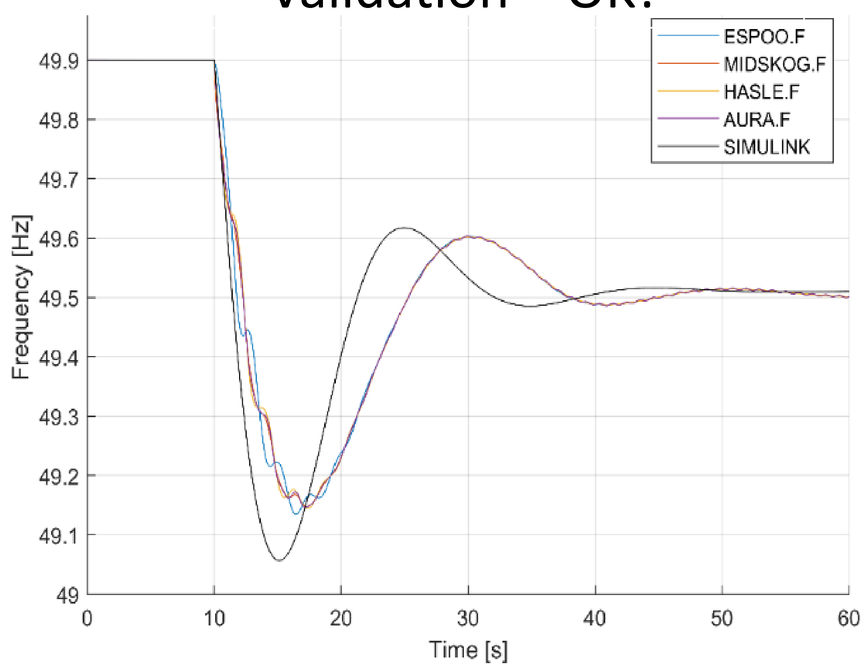
Full scale dynamic RMS model ~9000 buses

One bus dynamic model

$\sum H_i = H$

$\sum K_{FCR,\,i} = K_{FCR}$ [MW/Hz]…

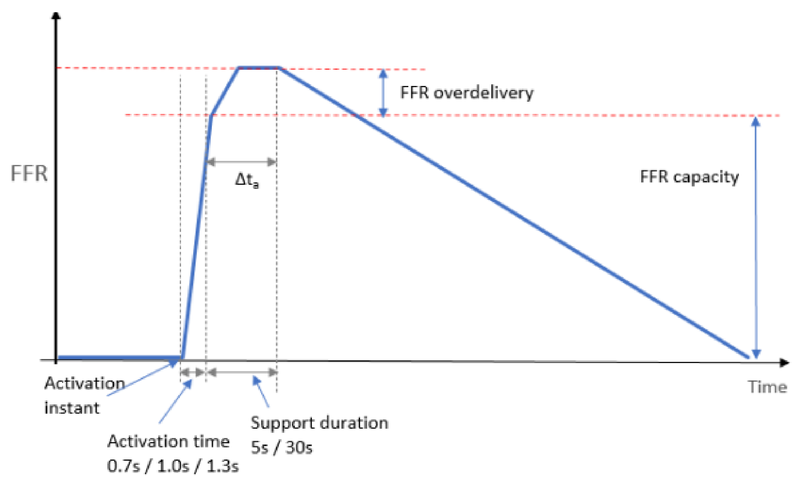
Validation – OK!



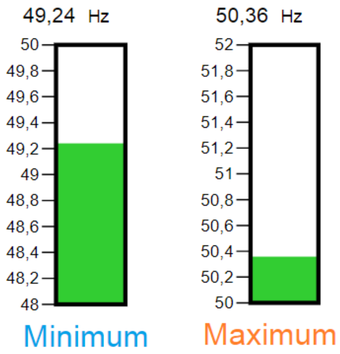
Validation of one bus model to full scale Nordic model – Simulation of frequency disturbance

Use cases

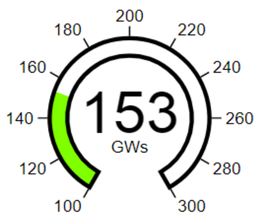
- EMS control room implementation
- Development of Fast Frequency Reserve, FFR
- Design of technical requirements for the Nordic FCR

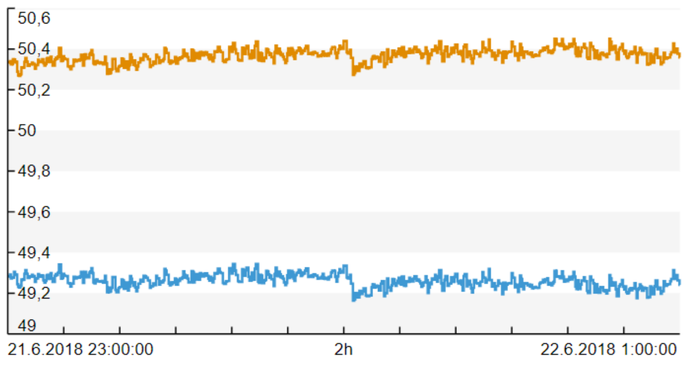


Estimated N-1 frequency



Kinetic energy





entsoe REPORT

FCR-D design of requirements
VERSION 1 - 5 JULY 2017

Conclusion

- Simplified model provide very similar response when voltage load dependency is set to zero.
- Differences in the model responses are conservative, i.e. RMS model including more dynamics provide a slightly more damped response.

http://www.cigre.org

Study Committee C4

Power System Technical Performance C4

10814_2022

Assessment of the impact of simulation model complexity on frequency stability studies – case Nordic power system

Niklas Modig (Svenska kraftnät)
Robert Eriksson (Svenska kraftnät)
Mikko Kuivaniemi (Fingrid)

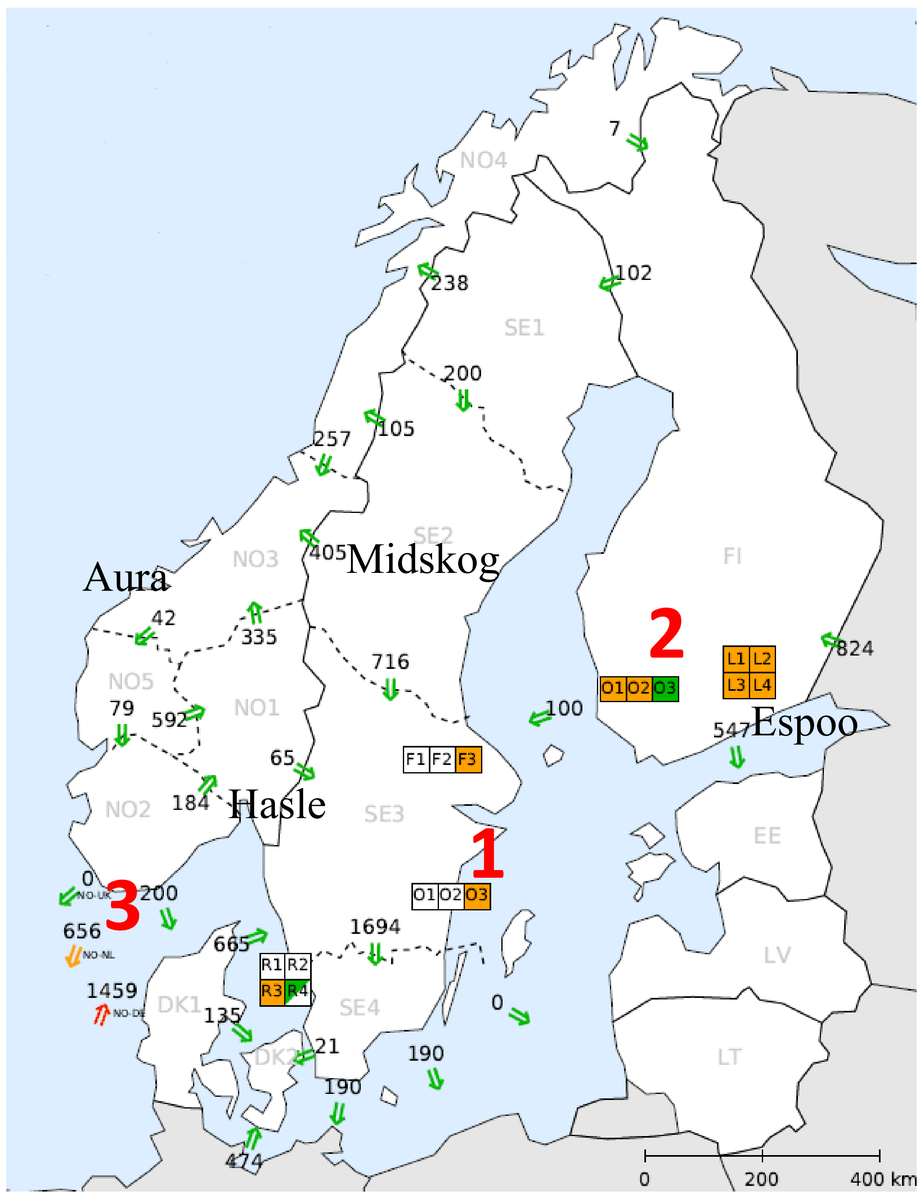
Disturbance

Disturbance location	Active power [MW]	Unit kinetic energy [GWs]
1. Southern Sweden (Oskarshamn 3)	1459	≈10
2. Southern Finland (Olkiluoto 3)	1459	≈15
3. Southern Norway (NordLink)	1459	0

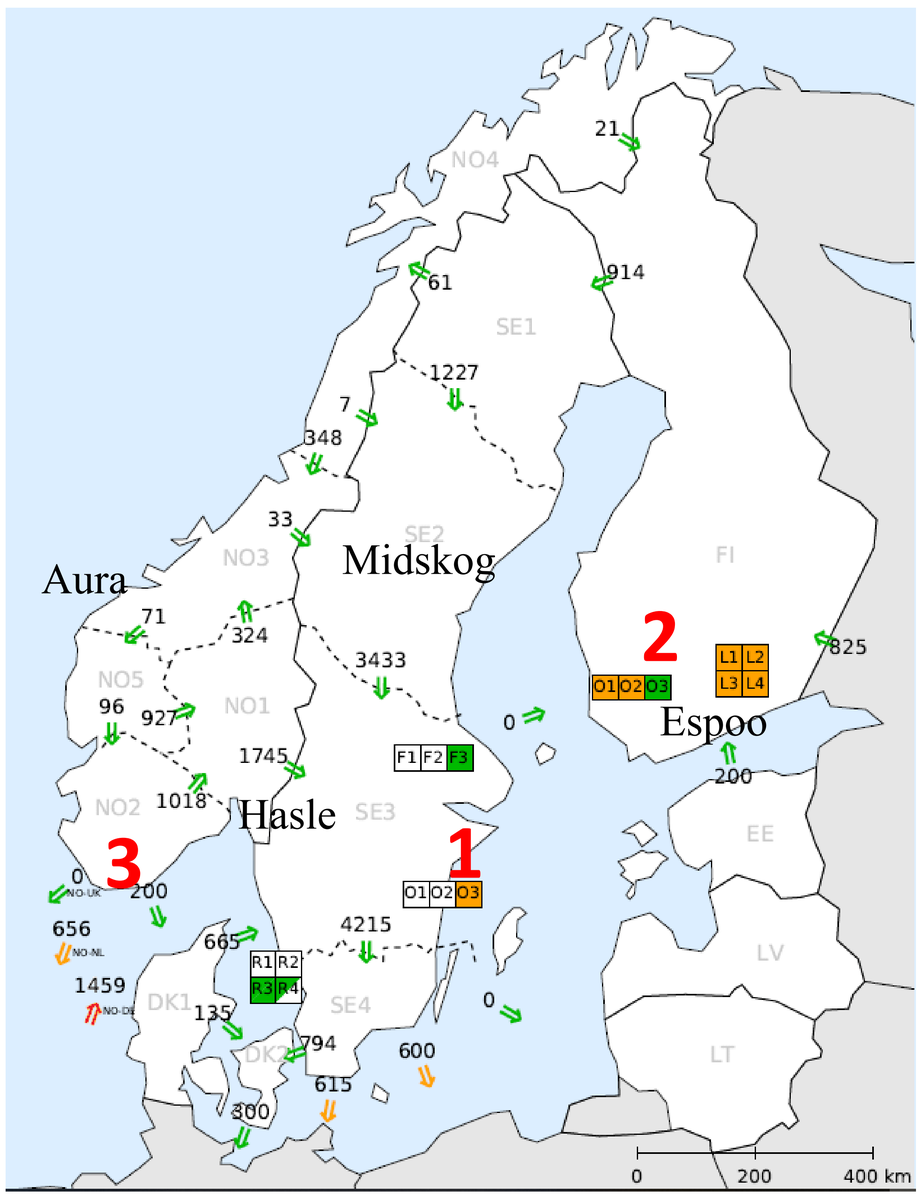
Compared settings

- PSS ON/OFF
- Load voltage dependence ON/OFF
- Load frequency dependence ON/OFF

Case 1 – Low power flow



Case 2 – Intermediate power flow



Results – Difference in frequency minimum

	Case 1	Case 2
Load voltage dependence - On	+0.11 Hz	+0.13 Hz
Load voltage dependence - Off	–0.06 Hz	+0.04 Hz
Load voltage dependence - Difference	+0.17 Hz	+0.09 Hz
PSS - On	+0.05 Hz	+0.12 Hz
PSS - Off	–0.01 Hz	+0.03 Hz
PSS - Difference	+0.06 Hz	+0.09 Hz
Load frequency dependence - On	+0.02 Hz	+0.07 Hz
Load frequency dependence - Off	+0.02 Hz	+0.08 Hz
Load frequency dependence – Diff	+0.00 Hz	–0.01 Hz

Study Committee C4
Power System Technical Performance C4
10814_2022

Assessment of the impact of simulation model complexity on frequency stability studies – case Nordic power system

Niklas Modig (Svenska kraftnät)
Robert Eriksson (Svenska kraftnät)
Mikko Kuivaniemi (Fingrid)

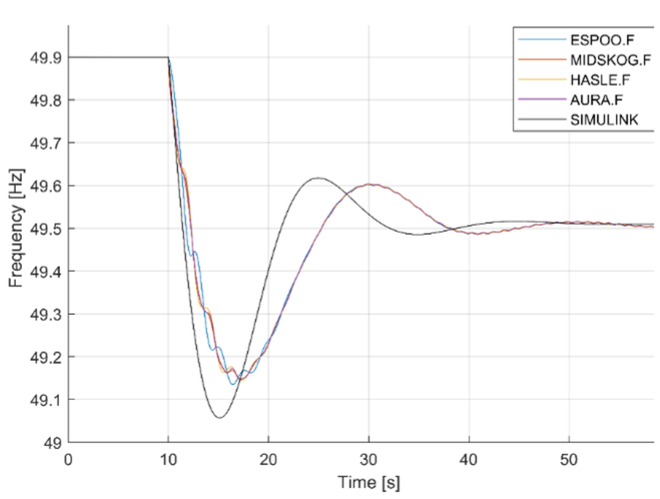


FIGURE 3: FREQUENCY RESPONSE COMPARISON FOR CASE 1, PARAMETER SET 1, DISTURBANCE: SOUTHERN SWEDEN, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: ON, PSS: ON.

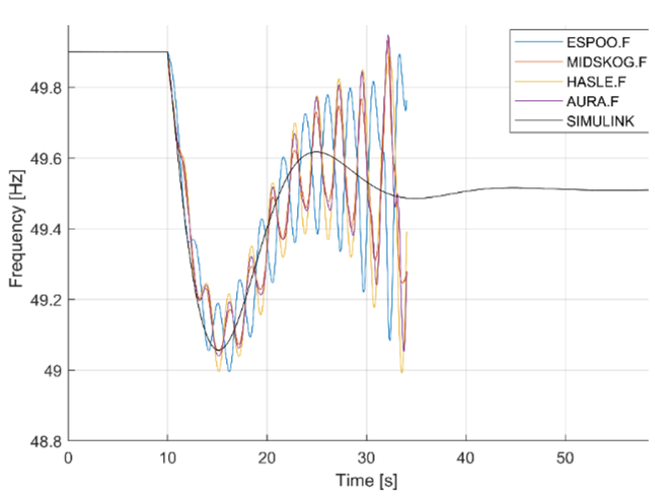


FIGURE 4: FREQUENCY RESPONSE COMPARISON FOR CASE 1, PARAMETER SET 1, DISTURBANCE: SOUTHERN SWEDEN, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: ON, PSS: OFF.

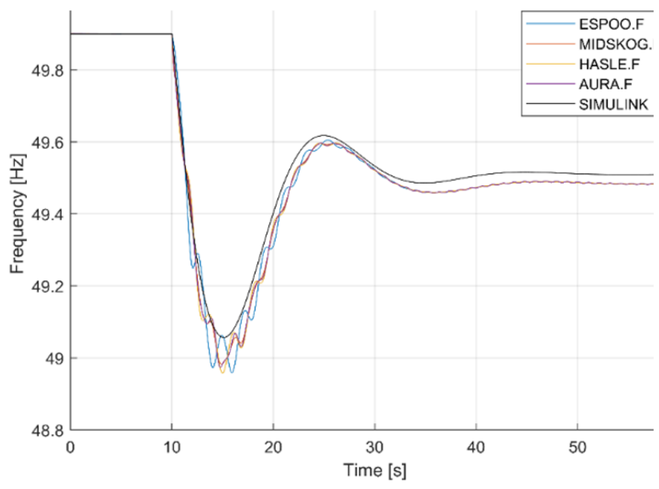


FIGURE 5: FREQUENCY RESPONSE COMPARISON FOR CASE 1, PARAMETER SET 1, DISTURBANCE: SOUTHERN SWEDEN, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: OFF, PSS: ON.

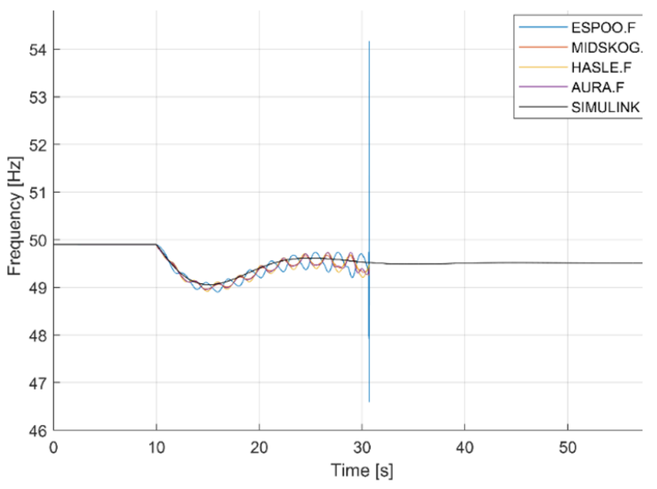


FIGURE 6: FREQUENCY RESPONSE COMPARISON FOR CASE 1, PARAMETER SET 1, DISTURBANCE: SOUTHERN SWEDEN, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: OFF, PSS: OFF.

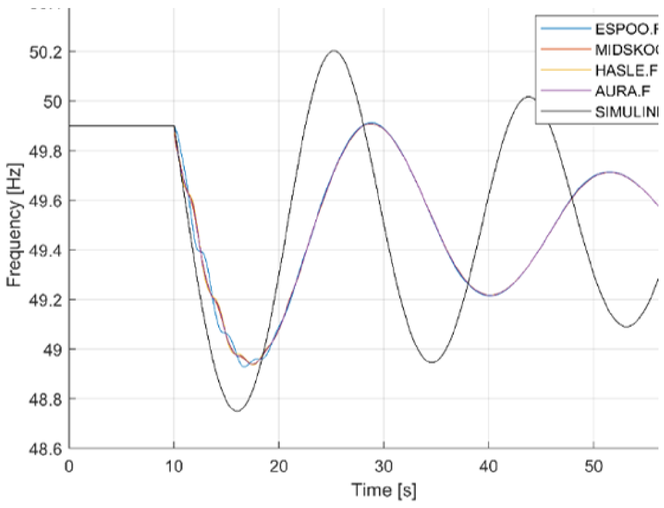


FIGURE 11: FREQUENCY RESPONSE COMPARISON FOR CASE 1, PARAMETER SET 2, DISTURBANCE: SOUTHERN SWEDEN, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: ON, PSS: ON.

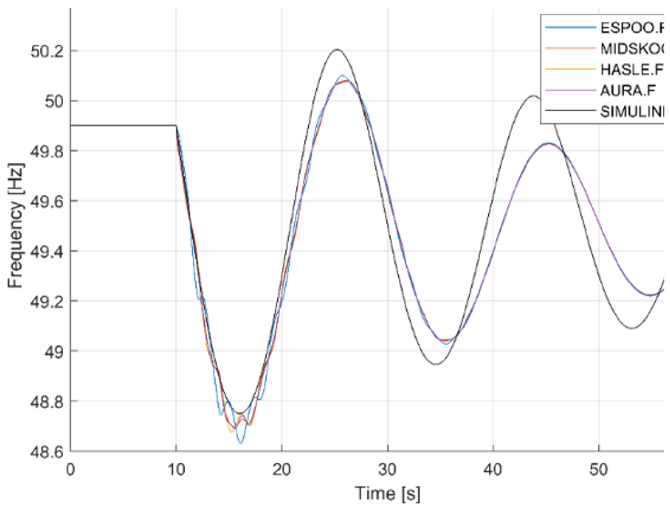


FIGURE 12: FREQUENCY RESPONSE COMPARISON FOR CASE 1, PARAMETER SET 2, DISTURBANCE: SOUTHERN SWEDEN, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: OFF, PSS: ON.

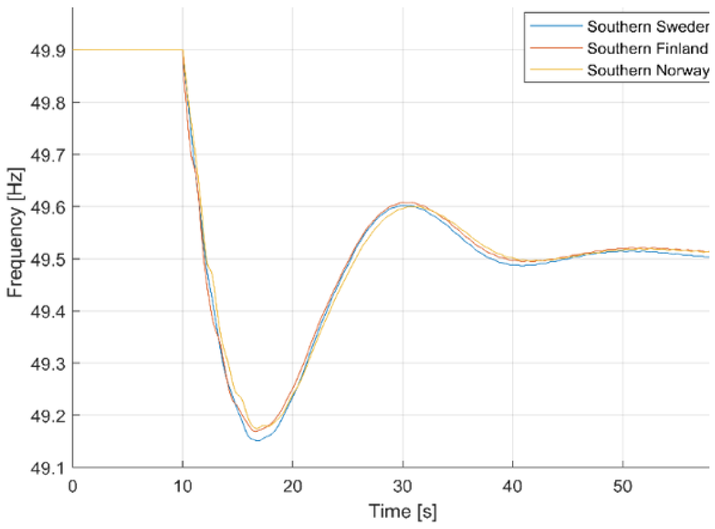


FIGURE 13: AVERAGE FREQUENCY RESPONSE IN PSS/E FOR CASE 1 WHEN THE DISTURBANCE OCCUR AT DIFFERENT LOCATIONS, PARAMETER SET 1, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: ON, PSS: ON.

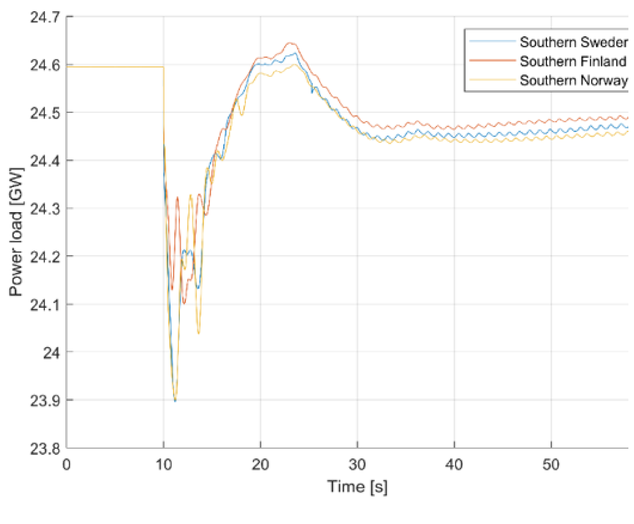


FIGURE 14: ACTIVE POWER LOAD FOR CASE 1 WHEN THE DISTURBANCE OCCUR AT DIFFERENT LOCATIONS, PARAMETER SET 1, FREQUENCY DEPENDENCE: ON, VOLTAGE DEPENDENCE: ON, PSS: ON.