Opponent's review of the Ph.D. thesis

Author: Ing. Le Thi Minh Trang
Title: Dynamic Model of Two Synchronous Generators Connected via Long Transmission Line
Doctoral Study Programme: Mechanical Engineering
Study Field: Power Engineering
Supervisor: prof. Ing. Ivan Uhlíř, DrSc.
Opponent reviewer: **Ing. Petr Neuman, CSc.**
                          NEUREG association, Prague

The opponent's review is based on comments on the following individual points.

1. Achievement of the set of the Dissertation Aims.

(i) To implement the complete system model for electromechanical oscillation of connected generators including mechanical components under steady state and disturbances condition.

Completed with reservation.
In the dissertation thesis elaborated at the Faculty of Mechanical Engineering, the opponent is assuming the Dynamic Model of Simple Power System incorporating mechanical analogies and a mechatronic view of the solution that would distinguish the evaluated dissertation from the solution at the Faculty of Electrical Engineering. Such a mechanical view is missing in this dissertation thesis.
In the dissertation thesis only the inertia constant H [sW/VA] of the individual synchronous generators is considered - see List of Symbols and Acronyms, Fig 4.8 Mechanical part model of the synchronous generator, equations (4.58), (4.60), (4.73).

(ii) To analysis the influence of the length of line for oscillation of power system using the complete system model.

Almost completely fulfilled.
In the dissertation thesis there is stated the existence of 500 kV line North - Central - South, in Vietnamese transmission power system, and the problems that this line causes. Unfortunately, these problems are not very detailed, even though Ing. Trang has dealt with their solutions already in the papers listed in the List of Articles Related to Dissertation (PI - Application Phasor Measurement Units, PII – using synchrophasors for control stability, PIII - Application PMU for the Vietnam 500kV Power System).

2. The level of analysis of the current state of the problem solved.
In Chapter 1. Introduction, first there is a brief overview of BlackOuts in the world, and especially the largest in India in 2012.
The blackout on 31 July is the largest power outage in history. The outage affected more than 620 million people, about 9% of the world population, or half of India's population, spread across 22 states in Northern, Eastern, and Northeast India. An estimated 32 GW of generating capacity was taken offline.

Specifically, there is a mention of Vietnamese PS and its operational problems.
Due to the geographical characteristics of Vietnam and different operational modes, the 500kV line linking North-Central-South power system often transmit the high capacity. Power transfer over this long line leads to heavy reactive losses and subsequent degradation of voltages at 500kV substations. These create high power swings in the regions and outweigh transmission capacity of power system.
According to the calculated results with the 2014 power infrastructure, voltage collapse occurred in the peak load hours on the Central linking line when it transmitted over 2400/1980 MW with 2/1 feeders.

Although the description of the operational problems is somewhat unclear, their inclusion in the dissertation has confirmed its focus in line with the assignment and main aims.

In Chapter 3. is Literary Research, to which the opponent has the following comments:
There are many times reffered Induction Motor and rotor has permanent magnets, simulation model of Permanent Magnet Synchronous Machine (PMSM) - see [22], [23], [29], [19], [31] and [33].
In the transmission system, however, PMSM motors are not used in High Voltage Level. PMSMs are used in distribution systems and low-voltage levels.
A similar situation is with the three phase salient pole synchronous machines (see [15], [27]), which are minimally used in TS.
Since SIMULINK schematics do not include the source literature (Fig. 4.11. Two-machine power system-simulation schematic, Fig. 4.12. Synchronous generator schematic, Figs. 4.13, 4.13, 4.13), it provokes the opponent to feel whether the SIMULINK models are the right models for a solved role in a dissertation that should be applicable in the Vietnamese transmission system.

Question 1: Has Mrs. Trang developed the models in SIMULINK itself or has she taken models from an existing block library, such as SimPowerSystems?

The opponent does not have enough experience to evaluate whether it is normal and appropriate to add a long list of computer programs [see APPENDIX (C)] to the dissertation?
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3. Theoretical contribution of the dissertation.
Theoretical contribution of the dissertation is unclear, the solution is not compatible with ENTSO-E's view of solving a long transmission line between two centers. In Vietnam, it is North (Hanoi) and South (Ho or Min) connected by a 500 kV line about 2000 km long.

From the theoretical and scientific point of view, there is nothing new in the dissertation.

3.1. Reviewer would appreciate the comparison of the proposed transient model with a more precise model of the 6th order, where the damper winding or non-linear magnetization saturation are, too.
The mathematical model of four-pole rotor synchronous motors with damper windings is reffered in [30], but the clear comparison of it is missing in simulation results.

3.2. **The simulations lack a more accurate description of the network model.**
The corresponding literature could be mentioned for the SIMULINK schemes.

Question 2: Why does the doctoral candidate propose replacing a long lead between the two centers of North (Hanoi) and the South (Ho-či-Min) with another lattice grid (mesh network)?

Reviewer agree with fact, that the performance of long AC transmission systems can be improved by reactive compensation of series or shunt (parallel) type. Series capacitors and shunt reactors are used to reduce artificially the series reactance and shunt susceptance of lines and thus they act as the line compensators. Compensation of the lines results in improving of system stability and voltage control, in increasing the efficiency of power transmission, facilitating line energization, reducing temporary and transient overvoltage. So far the practical method of improving line regulation and power transfer capacity is to add series capacitors to reduce line inductance; shunt capacitors under heavy load conditions; and shunt inductors under light or no-load conditions.

On the other side, reviewer do not agree, that the above methods are generaly impractical and uneconomical for power frequency lines. The proposed method which changes the line model to another model of mesh grid network is practicaly not realizace i Vietnam (especially for geographic reasons - the narrow territory of Vietnam in the middle of the state).

In the Vietnames Transmission System, it would be inappropriate to build a "mesh-network" instead of one North-South corridor just to increase corridor stability. Building a new infrastructure would also be very demanding and inefficient.

This change to another mesh grid could be used only as a Benchmarking analyse.

4. The practical benefit of the dissertation.
The practical benefit of the dissertation is not clear.

Question 3. Could you explain us the usability of your results for the Vietnamese transmission (or Distribution) system?

5. Suitability of the methods used.
The methods used in the dissertation are predominantly standard.
Interesting and unusual is the use of Kron's reduction.

Question 4: **What is the physical-electrotechnical interpretation of KRON's reduction formula from the theoretical point of view ?**
- see Chapter 4.4 Mathematical model of the proposed power system, the preliminary calculations /page 46, equation (4.106)/.
In the final step 5. there are eliminating all the nodes except the internal generator nodes using Kron reduction, and [Appendix (A.3)].

6. How the methods have been applied.
Question 5: What is the benefit of using the KRON's reduction for Modelling, Simulation, Operation and Control of Two Synchronous Generators Connected via Long Transmission Line?

7. Whether the PhD student has proven relevant knowledge in the field.
She has proven appropriate knowledge in the field.

8. The formal level of the work.
The formal level of the work is good and corresponds to the requirements for the dissertation.

9. Concluding remarks on the defense.
Finally, my overall opinion is that the PhD thesis fullfiled the set of the Dissertation Aims with reservations.

Yet **I recommend this PhD thesis for defense**.

In Prague on December 13th, 2018

Ing. Petr Neuman, CSc.