CHAPTER 7

CONCLUSIONS

7.1 Summary of the Results

This thesis concerns about developing program to calculate state space model of a plant which consists of power systems with HVDC links. The program is useful to analyze and design controls of various plants within the system, including HVDC control. The program is developed with its capacity to handle typical actual power systems which consist of some generators, some HVDC links, also many buses and branches.

This thesis gives modeling of power system with HVDC links. An algorithm to generate the linearized state space model is detailed discussed. Moreover, flows of the developed program are also explained. We use the popular Western System Coordinating Council (WSCC) 3-machine, 9-bus system to validate the obtained eigenvalues and participation factor of developed program. Furthermore, the developed program is tested using the Southern Thailand generation and transmission systems with 5 generating units, 1 HVDC link, of which it is connected to Malaysia, and the 28-bus and 41-branch AC transmission network. It is found that the program can function well.

Some notable observations regarding small-signal dynamic behaviors of the Southern Thailand system include :

- In the case there is no HVDC in the system, we see that there are 6 modes indicate local oscillation problems.
- From the resulting eigenvalues, it shown that with the presence of HVDC, the system can be unstable if certain parameters such as : K_r, K_i, T_r, and T_i are poorly tuned.
- When we have HVDC in the system, we investigate that there are 6 modes indicate local oscillation problems and 2 modes indicate global oscillation problems.
- From plotting voltage profile in each bus, we can see that after we import 300 MW power from Malaysia, voltage profile at each bus is better.
- After we import 300 MW power from Malaysia, we see that there is decreasing transmitted power in most of branches, specially branches which located in the northern part of the system interest.
- From PBH rank test for controllability, we found that there are 2 modes not full rank, it means those modes are not controllable. Those modes are eigenvalues number 1 and 38, and the biggest participation factor for those modes are state E_{fd} in generating unit number 2 and state R_F in generating unit number 2 . Because those two modes are uncontrollable, thus we cannot apply any controller in those states.
- From PBH rank test for observability, we found that there are 5 modes not full rank, it means those modes are not observable. Those modes are eigenvalues number 1, 2, 3, 9 and 38. The biggest participation factor are state E_{fd} in generating unit number 1 and 2, state V_R and R_F generating unit number 2. We cannot apply any observer-based controller to those states

The result can then be used for HVDC control design, thereafter.

7.2 Recommendations for Future Works

1. Study the effect of various parameters in the generator, exciter and HVDC to analyze small-signal stability in the system.
2. Changing load types, in this thesis we assumed constant power type, thus we can consider other types of load : constant current type and constant impedance type. We also can change loading level to see dynamic performance as the given operating conditions change.
3. Obtain actual parameters of generator data and HVDC data for the Southern Thailand systems to conduct further study.
4. State space representation of the system can be used for design of the controller to be implemented in the system, especially in HVDC link, such that it can help mitigate power oscillation occurring within actual power systems.
5. Interaction and coordinate controls of HVDC and other equipment such as excitation system, SVC can also be examined.