CHAPTER 5

CONCLUSIONS AND IMPLEMENTATION

5.1 Conclusions

Power system state estimation is an essential component of an energy management system. It is a statistical algorithm for determining the system state from a monitored set of system measurements and constraints. The challenge in developing a robust real time estimator is to satisfy the conflicting requirements of speed, accuracy and numerical stability.

In Chapter 4, the proposed orthogonal decomposition via Householder transformation method has been implemented in the 6-bus system, the IEEE 30-bus system and the practical 30-bus Sumatera Barat system. Theoretical analysis and test results have shown that the proposed method has superior numerical stability and convergence properties. It is a stable and appealing method to solve highly ill-conditioned power system state estimation problems at a competitive speed. Most importantly, the proposed method is shown to be feasible, efficient and effective in solving a practical system.

In addition, the ability of the orthogonal decomposition method to handle a wide range of weights obviates the need for special treatment of zero injection equality constraints. This greatly simplifies the state estimator implementation and makes the orthogonal decomposition method competitive with other solving methods, especially the well known numerically stable method, the Hybrid method.

From the literature survey, the prevalent approach for orthogonal decomposition system state estimator is the Givens rotation method. Instead of the Givens rotation method, this research has proposed the Householder transformation as the ordering method in the QR factorization and applies in the orthogonal decomposition method to solve the power system state estimation problem. Numerical examples in Chapter 4 have shown that the Householder transformation is able to perform better than the Givens rotation method in terms of computation efficiency with competitive numerical stability.

The disadvantage of the Householder transformation is that its application can cause severe "intermediate" fill-ins (non-zero elements generated by transformation); these fill-ins will be annihilated eventually, but they can cause excessive storage.

In conclusion, the orthogonal decomposition via Householder transformation method is an easy, feasible and accurate solving method for the power system state estimation problem that provides a good compromise between numerical stability and computation efficiency, thus making it competitive with other methods.

5.2 Future works

In the future, it may be desirable to investigate and enhance the transformation or the ordering technique of QR factorization as they are related to the convergence property of the solution method. This may potentially reduce the computation time and increase the accuracy in estimating the state variables, thus providing good base cases to other network security applications.

5.3 Implementation of power system state estimation

Power system state estimation plays a very important role in the monitoring and control of modern power systems. A present day implementation of system state includes additional functions in an operations control center computer system. The system gets its information about the power system from remote terminal units that encode measurement transducer outputs and opened or closed status information into digital signals that are transmitted to the operation center over communications circuits. In addition, the control center can transmit control information such as raise or lower commands to generators and open or close command to circuit breakers and switches. The information coming into the control center can be broken down into breaker or switch status indications, which are also called status data and analog data. The analog measurements of the generator output must be used directly by the automatic generation control (AGC) program, whereas all other data will be processed by the state estimator before being used by others programs.

In order to run the state estimator program, knowledge of the network topology is essential. It is the information of how the transmission lines are connected to the load and generations buses. Since the breakers and switches in any substation can cause the network topology to change, a network topology processor program must be provided to read the telemetered breaker or switch status indications and restructures the electrical model of the system.

The electrical model of the power system's transmission system is sent to the state estimator program together with the analog measurements. The output of the state estimator consists of all bus voltage magnitudes and phase angles, transmission line MW and MVAR flows calculated from the bus voltage magnitudes and phase angles, and bus loads and generations calculated from the line flows. These quantities, along with the electrical model developed by the network topology program, provide the basis for the economic dispatch program, contingency analysis program, and generation corrective action program.

Figure 5.1 shows the conceptual view of a real time power system modeling and state estimation.