Soft Switched Phase Shifted Full Bridge DC-DC Converter with Fuzzy Logic Controller

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Abstract—Soft Switched Phase Shifted DC-DC converters are used lots of industrial areas such as electric vehicles, uninterruptable power supplies, fuel cells, solar panel cells as energy sources are searched in order to improve the quality of power at the transmission, distribution lines and other areas. The main contribution of this paper, applying the most common used control method on single phase isolated bidirectional full bridge dc-dc converter and comparing this control method (Extended Phase Shift EPS) on efficiency way by with/without using snubber capacitors. In this paper, Isolated Bidirectional DC- DC Converter topology is modelled and controller algorithm is written by FORTRAN programming language. According to the results, it is observed that efficiency result of the converter, using snubber capacitors in the converter topology has higher performance than the snubberless system.

Keywords—DC−DC Convertor, Adaptive Load Frequency Control, Differential Evolution, Fuzzy Logic.

I. INTRODUCTION

The stability of the power system is one of the fastest growing research area of electricity in which contributed electricity demand. Integration of stability into the power systems typically desires long distance transmission lines to transmit power to the suitable place. Inter-area oscillation is a significant issue faced in long distance transmission of power in which groups of generators in one area oscillating against another groups of generators in other areas. Inadequate damping torque is the main factor of interarea oscillation leading to rotor angle separation and blackouts [3]. Inter- area oscillations can edge the electric power transfer between the areas. It was exposed that synchronous generators with Power System Stabilizer (PSS) can provide sufficient damping to transfer more power [4]. Therefore, it is necessary to understand the risks of interarea oscillations in the power systems integrated with wind power plants, and develop miti- gation control techniques to address these issues. An auxiliary power oscillation damping controller is designed and added to the wind turbines to enhance the damping of low frequency interarea oscillation modes.

Present power systems embedded with real time monitoring and control make them the most dependable critical infrastruc- tures. In the smart grid systems, the wide area monitoring is achieved by gathering system information in real time using synchrophasors including Phasor Measurement Units (PMUs) and Phasor Data Concentrators (PDCs) [5-6]. The synchrophasors can improve the reliability of power systems integrated with renewable energy sources like the wind power and solar by triggering the corrective actions for accounting the unpredictable power generation. The PMUs measure voltage, current, and frequency and transmit these measurements to PDCs which is then send to Energy Management Systems (EMSs) to perform state estimation and present synchrophasor data to control centers. PMUs communicate to the control cen- ter using network connections. The use of network connections makes the system ulnerable to cyberattacks. Cybersecurity and intrusion detection of network are important requirements for maintaining the integrity of wide area monitoring and protec- tion schemes [7- 9]. The intrusion detection method analyzes the measurement data to detect any possible cyberattacks on the operation of smart grid systems.

II. CLASSIFICATION OF POWER SYSTEM STABILITY

Power system stability is an indispensable requirement for protected and reliable operation of power system. An inclusive understanding of power system instability consequences is crucial for reliable power system analysis and operation. Power system stability has been defined and classified by the Institute of Electrical and Electronics Engineers (IEEE) and International Council for Large Electric Systems (CIGRE) as follows [10]: The capability of synchronous machines to stay in synchronism after a disturbance is referred to rotor angle stability. It relies on the ability of each synchronous machine to preserve equilibrium between input mechanical torque and output electromagnetic torque in the interconnected power system. Instability can cause acceleration or deceleration of the rotor of the synchronous machine and result in angular difference. If the angular separation between synchronous machines goes beyond a certain limit, according to power-angle curve the power transfer will be reduced. The output electromagnetic torque of perturbed system can be divided into two parts:

1) Damping torque: In phase with the speed deviation.

2) Synchronizing torque: In phase with rotor angle diver- gence.

Figure 1 shows the power system stability classification in terms of the aforementioned classes and subclasses The lack of damping and synchronizing torques can cause oscillatory and non-oscillatory instabilities, respectively. Rotor angle stability can be classified into the following categories:

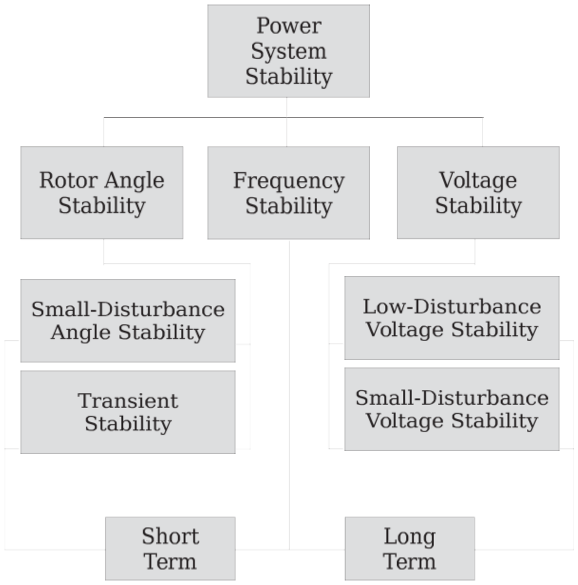

Fig. 1. Classification of Power System Stability

III. LITERATURE REVIEW

There exists a considerable research effort for the develop- ment of adaptive power system stability control technique.

A. Inter-Area Oscillation of Interconnected Power System

The inter-area oscillation of low frequency modes are essential characteristics of interconnected power system. Inter-area oscillations involve a group of synchronous generators in one area swinging against the ones in other areas. The interarea oscillation modes are identified using the right eigenvectors associated with the synchronous machines rotor speed which is referred to as mode shape. Inadequate damping torque is the main factor of interarea oscillation leading to rotor angle separation and blackouts. Interarea oscillations can limit the electric power transfer between the areas. For example, power transfer capability in it has been restricted by stability considerations for several years. Insufficient damping torque had resulted in tie-line separation. The initial plan was to transfer 2000 MW through ac lines, but stability analysis showed that power flow more than 1300 MW cannot be transferred due to insufficient damping torque. Then, it was discovered that synchronous generators with Power System Stabilizer (PSS) can provide sufficient damping to transfer 1800 MW. Therefore, it is necessary to understand the risks of interarea oscillation, and develop mitigation control techniques to address these issues. The PSS is used to enhance damping to the generator rotor oscillations by controlling its excitation system via an auxiliary control loop [43-45]. The power system stabilizer produces a damping torque component in phase with the rotor speed deviations. The PSS input signals can be either the rotor speed deviation, $\Delta\omega$, or the synchronous machine acceleration power,

$$P_a = P_m - P_e$$

which is the difference between the mechanical power and the electrical power.

B. Model of Interconnected Power System

For simulation resolves of synchronous and asynchronous machines, the following parameters are defined:

1) Standard parameters: These parameters can be ob- tained by observing the responses at the machine ter- minals with suitable test responses.

2) Fundamental parameters: These parameters determine the electrical characteristics of the machine, but they cannot be specified from the machine test responses.

Synchronous machines are parameterized using standard or fundamental parameters and asynchronous machines are pa- rameterized using fundamental parameters.

IV. PROPOSED METHOD AND RESULTS

A. Cybersecurity of Power System

The generation, transmission, and distribution of electric power systems embedded with real time measurements make the smart grid the most dependable critical infrastructure in the world. The present monitoring systems depends on state estimation, which is based on the Supervisory Control and Data Acquisition (SCADA) systems for the collection of data from field devices such as Remote Terminal Units (RTUs) and sent up to the central control center. In the future, the wide area monitoring of smart grid systems will be accomplished by collecting system level information in real time by using Phasor Measurement Units (PMUs) and Phasor Data Concen- trators (PDCs). The data obtained from PMUs will be used for the state estimation and implementation of control strategies for optimal control of smart grid systems. The PMUs which are also called synchrophasors provide accurate measurements of active power, reactive power, voltage, current along with phasor angles in real-time. The signal f (t) is used to calculate

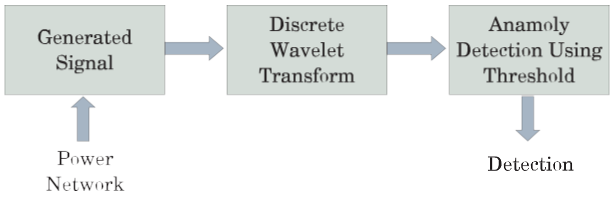

Fig. 2. Malicious Data Detection and Identification using Wavelet Analysis

the approximation and detail coefficients at level one. Then, the calculated approximation coefficients are utilized to obtain the approximation and detail coefficients at level two, and so on. Anomaly detection of malicious data in smart grids consists of three steps as indicated in Figure 2. The first step is to collect the measured data from the PMUs. The second step is the DWT to analyze the signal features. In the final step, the detail coefficient values are compared with predefined threshold values (confidence intervals) for the determination of the anomalies in the signal. If the data anomalies are considered as a random white noise with Gaussian distribution, for any random variable, choosing ±3σ confidence interval yields to:

$$P\ (\mu - 3\sigma < X \leq \mu + 3\sigma) \approx 99.6\%$$

This interval corresponds to 99.6% confidence level, which means that we can detect anomalies with 0.3% error rate.

V. CONCLUSION

The model-based intrusion detection requires high computational effort to obtain the power system dynamic model. However, the signal-based intrusion detection using discrete wavelet transform extract the statistical properties of the signal to detect the anomaly in different resolution levels. The detail coefficients at different levels contain high frequency characteristic of the signal. This method enables us to detect the anomaly faster than model-based method. Also, we can detect the anomaly in different resolution levels. The signal- based method is in real time and it is beneficial and efficient to detect any anomaly activities before damaging the power system.

REFERENCES

[1] D. Apostolopoulou, A. D. Domnguez-Garca, and P. W. Sauer, "An assessment of the impact of uncertainty on automatic gen- eration control systems," IEEE Transactions on Power Systems, vol. 31, no. 4, pp. 2657–2665, July 2016.

[2] A. K. Sahoo, V. Chitra, and T. Kanagapriya, "Load frequency control for a distributed grid system involving wind and hydro power generation," in Power, Control and Embedded Systems (ICPCES), 2012 2nd International Conference on, Dec 2012, pp. 1–6.

[3] D. Rerkpreedapong, A. Hasanovic, and A. Feliachi, "Robust load frequency control using genetic algorithms and linear matrix inequalities," IEEE Transactions on Power Systems, vol. 18, no. 2, pp. 855–861, May 2003.

[4] X. Yu and K. Tomsovic, "Application of linear matrix inequal- ities for load frequency control with communication delays," IEEE Transactions on Power Systems, vol. 19, no. 3, pp. 1508– 1515, Aug 2004.

[5] O. P. Malik, A. Kumar, and G. S. Hope, "A load frequency control algorithm based on a generalized approach," IEEE Transactions on Power Systems, vol. 3, no. 2, pp. 375–382, May 1988.

[6] A. H. Mazinan and A. H. Hosseini, "Application of intelligence- based predictive scheme toload-frequency control in a two-area interconnected power system," Applied Intelligence, vol. 35, no. 3, pp. 457–468, 2011.

[7] J. D. Glover and F. C. Schweppe, "Advanced load frequency control," IEEE Transactions on Power Apparatus and Systems, vol. PAS-91, no. 5, pp. 2095–2103, Sept 1972.

[8] H. A. Yousef, K. AL-Kharusi, M. H. Albadi, and N. Hossein- zadeh, "Load frequency control of a multi-area power system: An adaptive fuzzy logic approach," IEEE Transactions on Power Systems, vol. 29, no. 4, pp. 1822–1830, July 2014.

[9] S. Nag and N. Philip, Application of Neural Networks to Auto- matic Load Frequency Control. Cham: Springer International Publishing, 2013, pp. 431–441.

[10] Y. Oysal, A. S. Yilmaz, and E. Koklukaya, Adaptive Load Frequency Control with Dynamic Fuzzy Networks in Power Systems. Berlin, Heidelberg: Springer Berlin Heidelberg, 2005, pp. 1108–1115.

[11] S. K. Pandey, S. R. Mohanty, N. Kishor, and J. P. S. Catala˜o, An Advanced LMI-Based-LQR Design for Load Frequency Control of an Autonomous Hybrid Generation System. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 371–381.

[12] R. Umrao and D. K. Chaturvedi, A Novel Fuzzy Control Approach for Load Frequency Control. India: Springer India, 2013, pp. 239–247.