Tie-Line Bias Control of a Power System with Variable Renewable Energy Generation

Iroshani Jayawardene, *Student Member, IEEE*, Ganesh K. Venayagamoorthy, *Senior Member, IEEE*
Real-Time Power and Intelligent Systems (RTPIS) Laboratory
The Holcombe Dept. of Electrical and Computer Engineering
Clemson University, SC 29634, USA
Emails: ijayawardene@gmail.com, gkumar@ieee.org

***Abstract* - In this study, a two-area power system with large MW PV plants was considered, in which Area 1 provided power interchange to Area 2. To minimize power fluctuations and maintain the desired system frequency while concurrently maximizing the penetration of PV power into Area 2, automatic generation control (AGC) with tie-line bias control was implemented. The objective was to increase/decrease generations in Area 1, thus varying the tie-line power flow to balance out the PV power variability. Furthermore, the output power of the PV plant used in Area 1 AGC control was predicted based measurements obtained from a phasor measurement unit at the PV plant bus. Typical results are shown for the steady state, variable PV generation and large tie-line disturbance conditions.**

Index Terms—Large PV plants, neural networks, ***phasor measurement units, predictions, tie-line bias control, tie-line power flow and frequency control***

I. Introduction

The increasing penetration of uncertain and variable renewable energy into the transmission grid introduces challenges in real-time power system operation. A large photovoltaic (PV) system or a wind farm's power output fluctuation due to weather conditions (irradiance, temperature, wind speed and direction) causes the system's frequency to fluctuate. The power and frequency fluctuations in systems with large MW variable generation raise dynamic and transient stability concerns. In this study, a 200 MW PV plant was connected to a two-area, four-machine system, as shown in Fig 1.

In order to maintain the system's frequency and tie-line flows, a secondary control, AGC, was implemented such that each area had its own regulator. The block diagrams of the AGCs in Areas 1 are shown in Fig 2. Fig. 3 shows the tie-line power variations without predictions of the variable generation used in the Area 1 AGC. The control can be improved by predicting the PV plant generation using a neural network, and replacing the real-time PV plant generation value with the predicted value in the tie-line bias control. The predictions intervals studied are 30 to 90 seconds. Optimal prediction step size has to be determined for the best control.

II. Key Figures

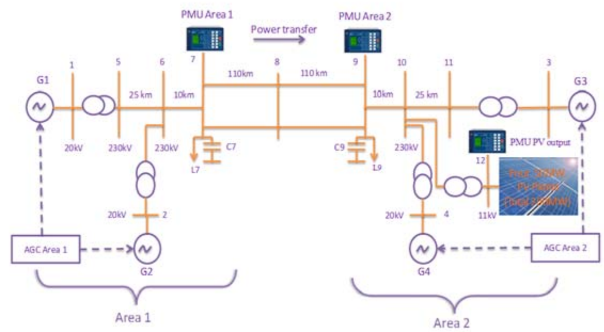

Fig 1. 200 MW PV plant integrated into a two-area power system.

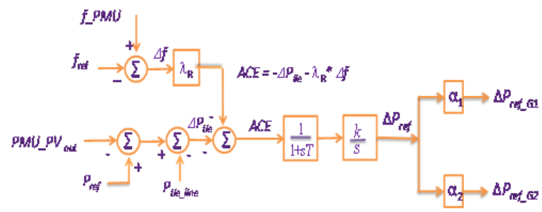

Fig 2. Area 1 AGC functional diagram for the power system shown in Fig 1.

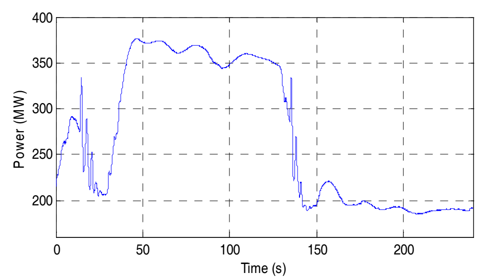

Fig. 3. The tie-line power variations.

References

[1] S. Eftekharnejad, V. Vittal, G. T. Heydt, B. Keel, and J. Loehr, "Impact of increased penetration of photovoltaic generation on power systems," *IEEE Transactions on Power Systems*, vol. 28, no. 2, May 2013, pp. 893- 901.

[2] G. K. Venayagamoorthy, "Tie-Line Bias Control of a Power System with Large PV Plants Using PMU Information", *XIII Symposium of Specialists in Electric Operational and Expansion Planning*, May 18-21, 2014, Foz do Iguacu (PR), Brazil.