Center for Advanced Power Systems (*CAPS*) at Florida State University

Notional Dynamic Model Development of Florida Grid for Assessing the Impact of Renewable Energy Integration

4th International Conference on Integration of Renewable and Distributed Energy Resources
December 6 - 10, 2010
Albuquerque, USA

FESC Florida Energy Systems Consortium

T. Alquthami, H. Ravindra, J. Langston, K.Schoder, M. O. Faruque, M. Steurer, R.Meeker, S. Dale, T. Baldwin, P. Mclaren

Objective

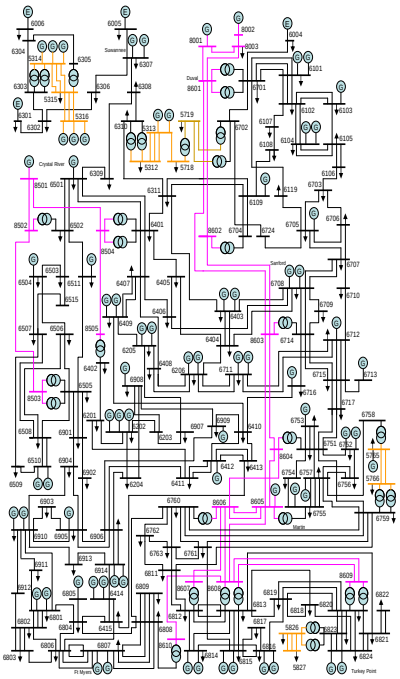
Observe and analyze the impact of Penetration of large PV power on the notional dynamic model of the Florida Transmission Grid.

Research Approach

- Develop notional/representative dynamic models of Florida Grid for research purposes
- Perform case studies by integrating PV and asses the impacts

Notional Florida Grid Model

- 154 bus model was built in PSS/E
- Bus Voltage levels at 500kV, 230kV, 138kV level
- 76 Generators with a scheduled 48049.72MW
- 116 Loads totaling 47704.2MW, 7999.2MVar
- Dynamic data for Machines, Governors, Exciters and Stabilizers are used

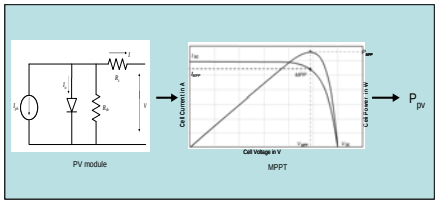


User-written PV model

- Single diode PV model equation:

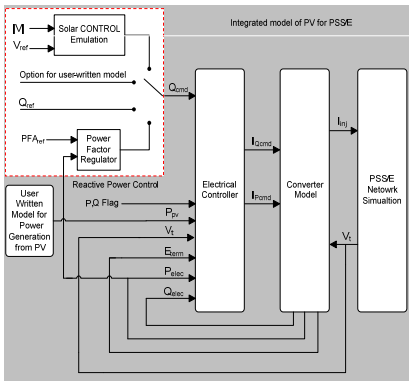
$$I = I_{ph} - I_0\left\{\exp\left[\frac{qV}{nkT}\right]-1\right\}$$

- Incremental Conductance Maximum Power Point Tracking (MPPT) is employed



Integration of PV Model in PSS/E

- The PV model and MPPT code are written in FLEX/FORTRAN and scripted in the CONEC File
- CONEC file is compiled to create a user DLL file
- The model is then incorporated with the electrical control and converter model of Type 4 wind turbine model available in PSS/E

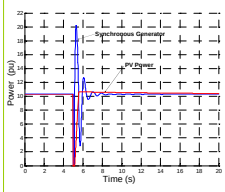


- PV units added at various BUS for 20% penetration for a total of 9709.5MW
- PV units are added by replacing the existing Synchronous Generator units
- Case studies are performed using PV integrated Florida Grid Model

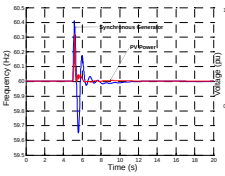
Results of Simulation Case Studies

Case 1 – Fault at a Bus

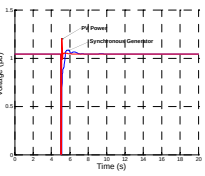
- A bus fault is applied at Bus 6504 with a fault impedance of 0.01 Ohm for 9 cycles.
- The Synchronous Generator unit at BUS 6504(with P=1030MW) is replaced with PV unit.
- The Solar Irradiance is assumed to remain constant at 1000Wm^{-2}.



Power at Bus 6504



Frequency at Bus 6504

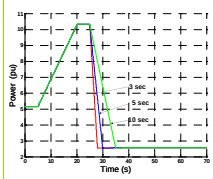


Voltage at Bus 6504

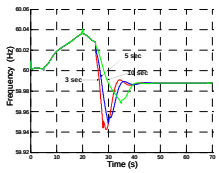
- After the fault is cleared, Synchronous Generator (SG) unit showed oscillation in power whereas PV unit does not show any significant oscillations.
- The frequency deviation for the SG is higher than that of PV unit.

Case 2 – Cloud Cover/Sudden drop in irradiance

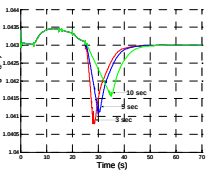
- A cloud cover scenario is simulated at bus 6504 using different ramp rate.
- The Solar Irradiance is dropped from 1000Wm^{-2} to 250Wm^{-2} in various time durations of 10sec, 5sec and 3sec.



Power at Bus 6504



Frequency at Bus 6504



Voltage at Bus 6504

- It can be observed that even with the power drop from 100 to almost 25% in 3 sec the system still operates well under the protection system settings.

Future Work

- Validating notional Florida Grid model with necessary cooperation from Florida Reliability Coordinating Council (FRCC).
- Further refining the model and adding more dynamics into the existing model
- Incorporating solar variability model into the PV model and observe the Impact of Cloud cover pattern.