Development of Smart PV Inverters for the Smart Grid

Yahia Baghzouz, PhD, PE
Prof. of Electrical Engineering
UNLV
Past Electric Grid

- Power generation from large power plants
- Unidirectional Power flow
- Limited automation
- Limited monitoring
- Communication system up to the substation
- Feeder outage report – rely on customer calls
- Etc ...
Past Induction-Type Energy (kWh) Meter

- Records Energy consumption by integrating power over time.
- Meter read monthly on site by meter reader
Future Electric Grid

- Power generation from conventional plants and distributed renewable resources
- Bi-directional power flow
- Highly automated and highly monitored
- New integrated devices and systems
- Broad communication system beyond metering point
Data Flow Diagram of Future Grid: TBD!
(Source: DOE Website)
Future (now) “Smart” Meter

- Records kWh, kVARh, power factor, peak demand, power quality indices, instantaneous power quantities, etc...
- Two-way communication with the utility (meter can be read instantly – no need for meter reader)
- Remote disconnect/reconnect, sends an alarm when tempered with
- Able to communicate with “smart” home appliances.
- Customers have internet access to their energy use (15 min intervals)
Other Smart Devices Coming Online
Today’s Grid-Tied PV Inverters

Today’s inverters are already smart as they
• monitor the PV array, track the maximum power and operate at that point,
• sense the presence of the grid, synchronize to and inject a current in phase with the voltage,
• monitor the grid and disconnect in case of trouble (e.g., swings in voltage or frequency).

![Diagram of a grid-tied PV inverter system]
Today's Grid-Tied PV Inverters

Maximum Power Tracking

Grid synchronization

Grid Monitoring - Disconnect
PV Power Characteristics on Cloudy Days

- PV power output variability follows solar irradiance variability.
- Dramatic variations in power swings can occur during partly cloudy conditions, and there is a growing concern about the effects this may have on the normal operation of the utility grid.
- Some industry professionals believe that this issue could limit the penetration of grid-connected PV.
PV power fluctuations lead to voltage fluctuations, which in turn can lead to:

- excessive operations of voltage regulation equipment (transformer LTC and Capacitor switching)
- voltage (or light) flicker
Proposed Solution

- Add an additional control feature: inject an appropriate amount of reactive current to maintain a steady value of the overall current.
- Computer simulations (PSCAD)
Some Simulated Results

- Current of conventional Inverter
- Overall current of new Inverter
- Reactive part of overall current
Next Step

- Hardware Implementation and testing – slow, frustrating, lack of resources, etc…

- Research on what it takes to switch the inverter from a grid-tie operation to an off-grid (islanded) operation.
Questions or Comments?