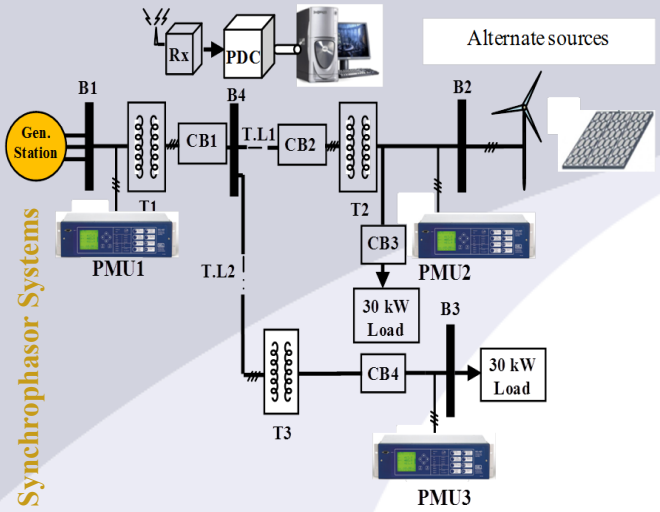
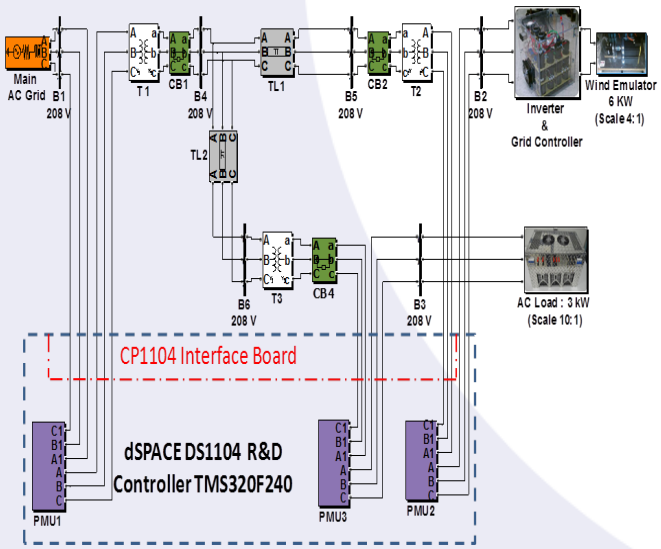
Wide Area Measurement Systems



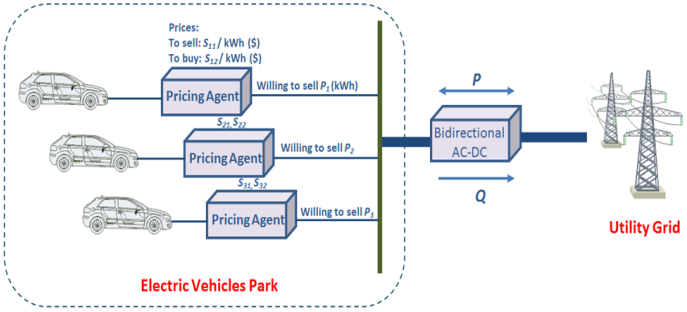
Synchrophasor Systems

- Implementing ideas for wide area monitoring and control of smart grids.
- Smart Grid Research targeting the achievement of an increase in the overall system reliability via significant dependence on WAMS.
- Performing studies on the depth of observability using the PMU .
- Studying the optimal location and number of PMUs used within a wide area power network.
- Defining communication requirements for higher bandwidth data network.



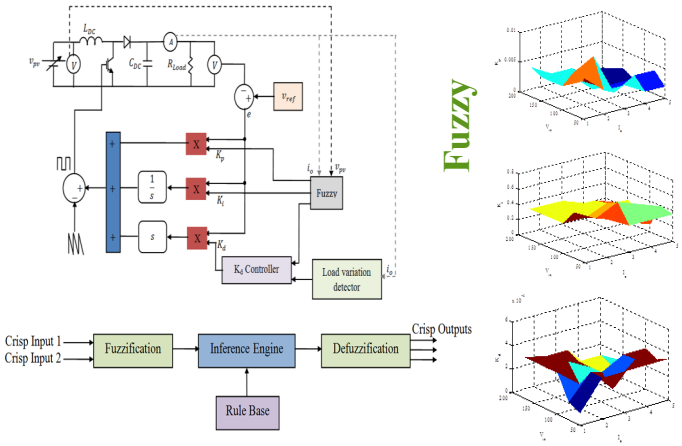
Charging Facilities for Hybrid Electric Vehicles

- Researching and developing V2G and Smart Energy Management
- Power sharing and Utilization of the Energy Stored in the Batteries
- Studying the utilization of power available in the charging station for voltage stability assessment on the utility grid.
- Developing real-time smart load management algorithms to improve smart grid performance with high penetration of EVs and PHEV.



Smart Control of Power Electronic Converters

- Developing smart controllers for power electronic converters
- Developing smart controllers to maximize the stable operating range of the DC-DC converter in PV systems by dynamically tuning the controller parameters at various loading conditions
- Developing smart controllers to enhance the transient response



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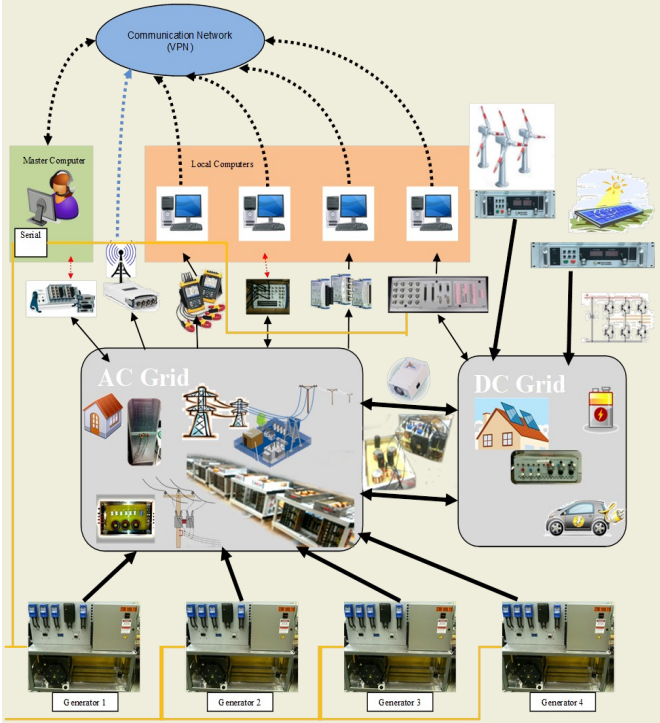
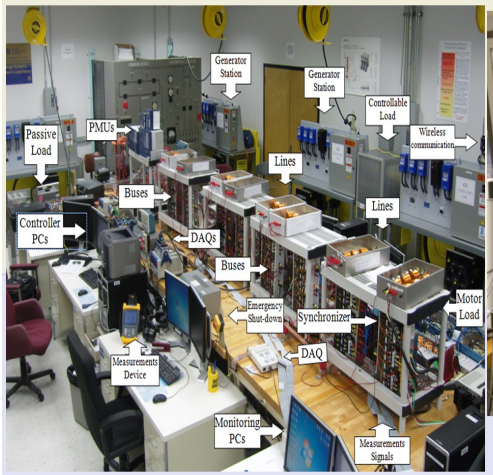
Smart Micro Grid Test-bed



Wide Area Monitoring, Control and Protection (WAMPAC)

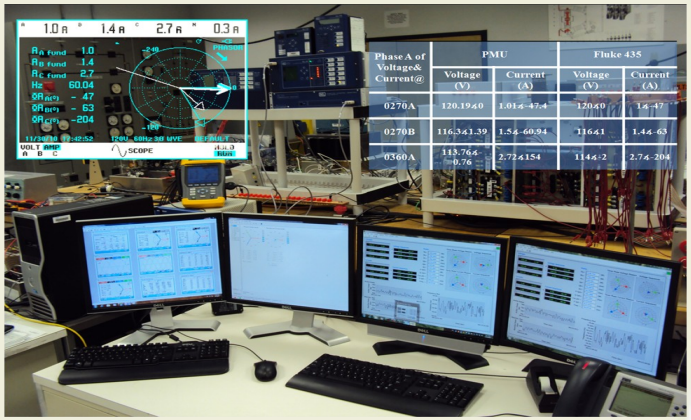
Wide Area Monitoring, Control and Protection (WAMPAC) involves the use of system-wide information and the communication infrastructure to send local information to a control center in order to counteract the propagation of large disturbances. New synchronized measurement technology (SMT), which enables WAMPAC are being developed by our research-



Phasor Measurement Units (PMU's)

Enables the use of advanced, smart monitoring tools to quickly and reliably estimate the real-time state of the systems. The PMU, measures the electrical waves on the electricity grid to determine the health of the system. These Synchrophasors are important measuring devices for the smart operation of power systems. Some major applications being conducted are:

- Real-time visualization of power systems.
- Detecting isolated networks and preventing total system blackout.
- Load management and other load control techniques such as demand response mechanisms to maintain power system stability.
- Increase the reliability of the power system by fast detection of faults, isolation of healthy system, and the prevention of power outages.
- Increase power quality by precise analysis and automated correction of power sources of the system.
- Wide Area measurement, protection and control, in whole area of the network, and local grids.



Synchrophasors as base for Wide Area Control System

- Control of HVDC, FACTS as fast reaction to power swings
- Fast control of generation and demand balance in a distributed manner
- Remedial action control to supply, facilitate corrective action of power system equipments

Synchrophasors as base for Wide Area Protection System

- Direct transmission of phasors between protection devices
- Could improve reaction of protection device
- Detect system inter-area and wide area abnormalities
- Detect and predict system instability situation

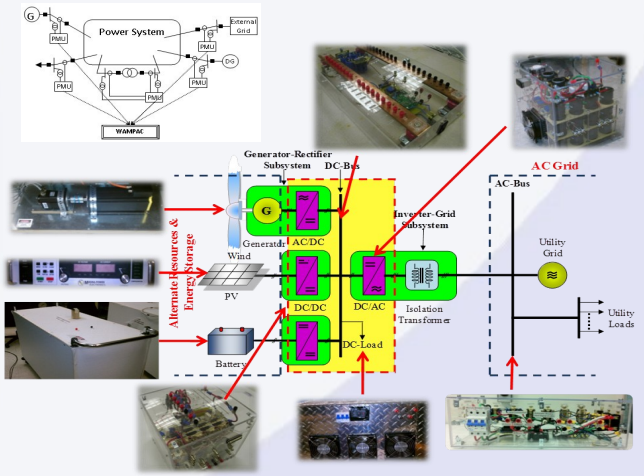
· **Increased network load to understand the mid-term dynamics by**
Online observation and offline disturbance analysis of voltage stability, frequency stability and power oscillations.

· **Phasor measurement is base technology for future smart grid features**

- System integrity protection schemes (SIPS)
- Power oscillation damping devices (FACTS, fast valving)
- Real time state estimator

Grid-Connected Sustainable Energy Sources

- Intelligent forecasting techniques to model photovoltaic systems, wind farm and demand power with high levels of accuracy.
- High Quality/Efficiency Power Electronic Converters are being developed for integration of sustainable energy sources into the power grid.
- Developing novel power electronic converter topologies and control techniques for smart utilization of sustainable energy power.
- Developing high frequency/high power converters for best performance and minimum weight.
- Developing bi-directional Power Flow control techniques between the AC and DC sides of microgrids including active and reactive power for load sharing and Compensation.
- Protection of the DC microgrids and the development of smart energy management techniques.
- Pulsed loads and smart algorithms for their mitigation are investigated.



Hardware Implementation for Grid Connected