TSDOS TRANSMISSION & SUBSTATION DESIGN & OPERATION SYMPOSIUM

THE UNIVERSITY OF TEXAS AT ARLINGTON

Review of Integrating and Controlling Distributed Energy Resources

Rekha Jagaduri, P.E
HDR

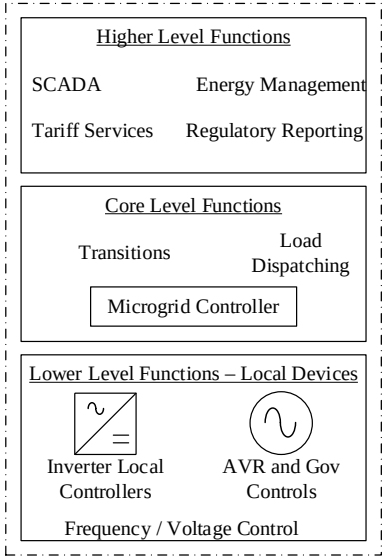
Outline

- Introduction
- Existing Standards and Frameworks
- Overview of Microgrid
- Overview of Proposed Microgrid Controls
- Overview of Proposed Microgrid Protection
- Conclusion and Future work

Introduction

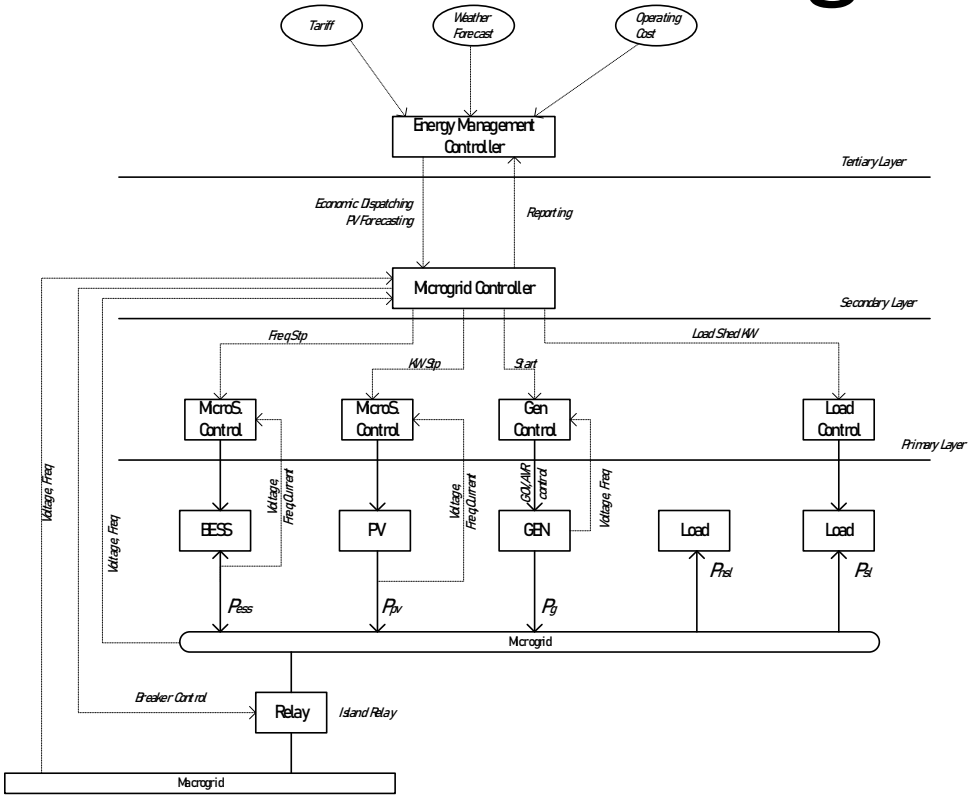
- Reliability and Resiliency
- Microgrid
- Distributed Energy Resources (DER)

Existing Standards and Frameworks

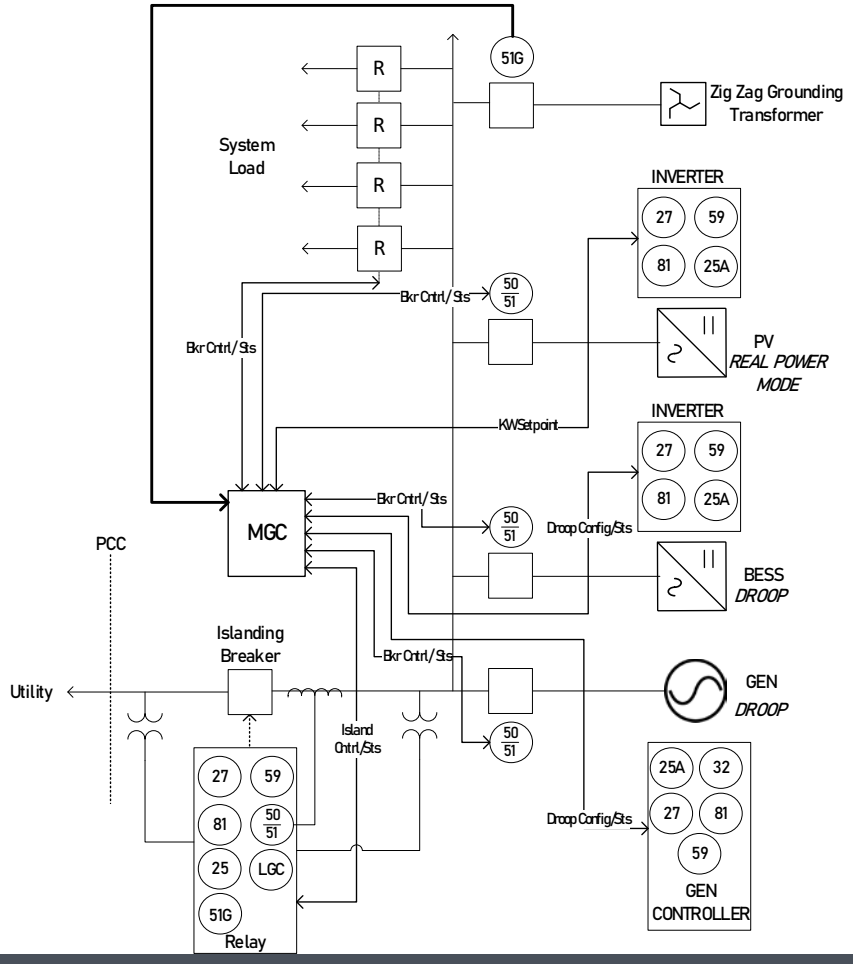


IEEE 2030.7 Levels of Control

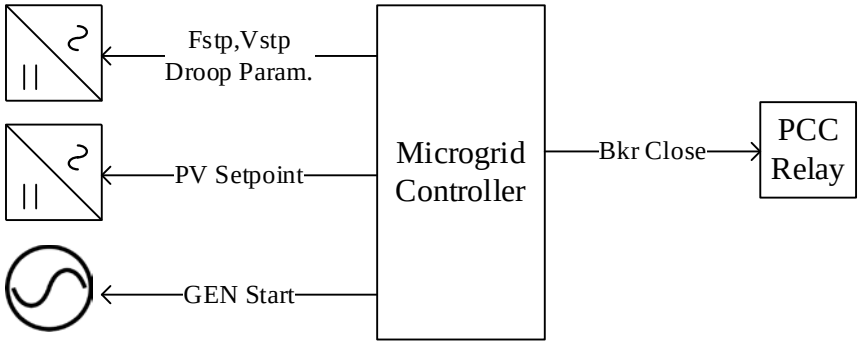
Overview of Microgrid



Typical Single Line Drawing



Overview of Proposed Microgrid Controls



Microgrid Control Interface

Microsource Controller

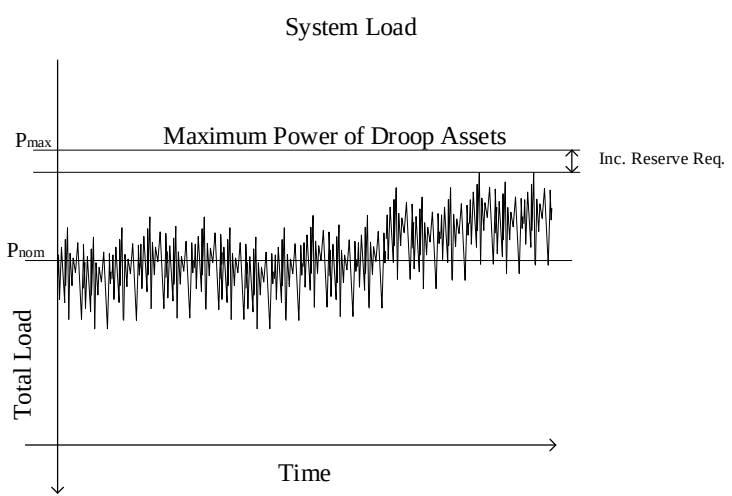
	PV Inverter	BESS Inverter	Diesel / Gas Engine
Grid Forming – Droop	No	Yes	Yes
Grid Forming – ISOC	No	No	Yes
Grid Following – Direct current Mode	Yes	No	No

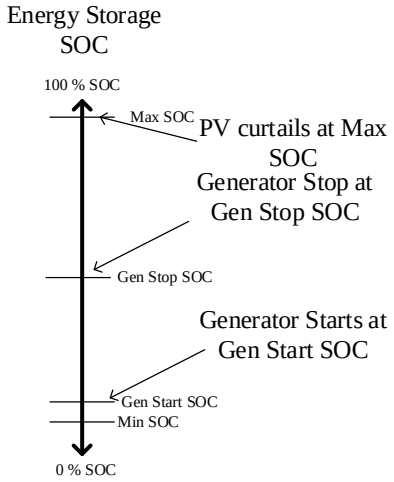
DER Modes of Operation

	PCC Breaker Status	BESS Control Mode	PV Control Mode	GEN Control Mode
BESS Only	Open	Grid Forming - Droop		
BESS + PV	Open	Grid Forming - Droop	Grid Following - Direct Current Control	
BESS+ PV+ GEN	Open	Grid Following - Droop	Grid Following - Direct Current Control	Grid Forming - Droop

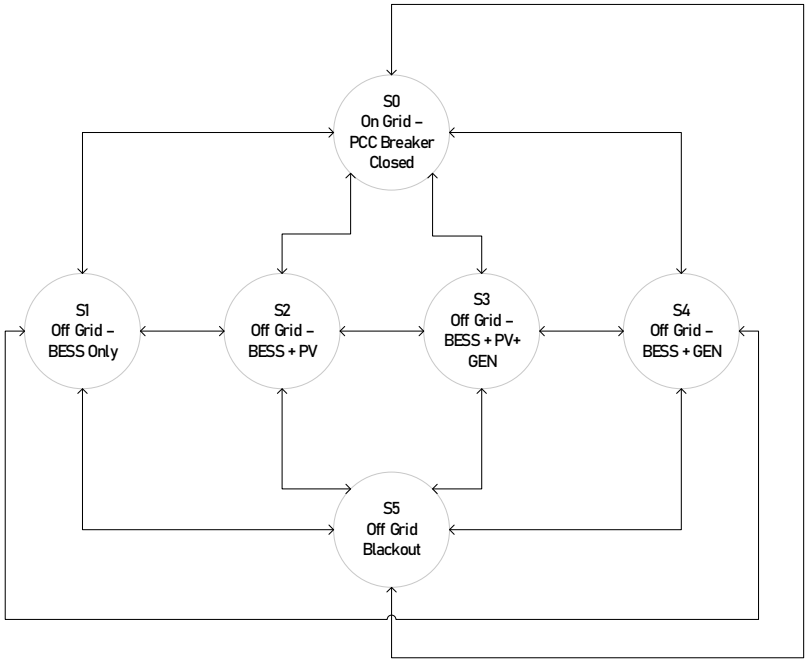
Microsource controller configuration under different Scenarios

Microgrid Controller Control Constraints





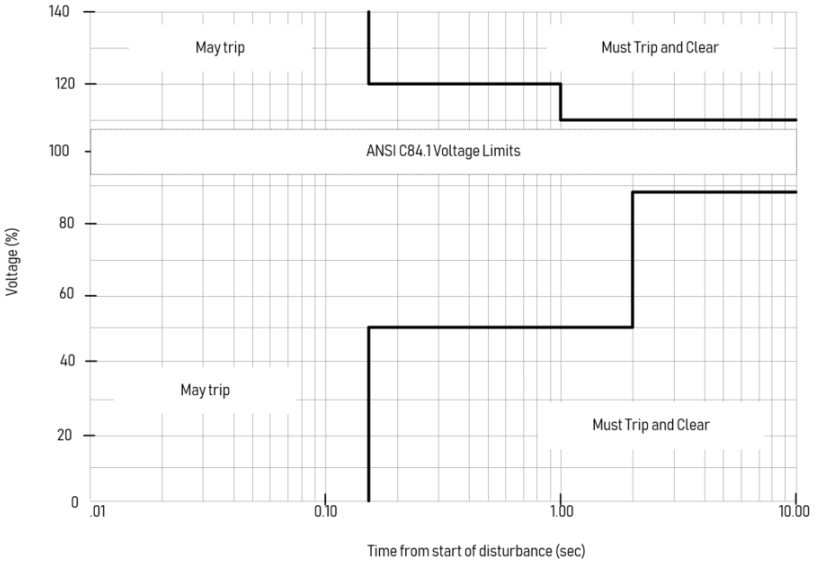
Microgrid State Machine

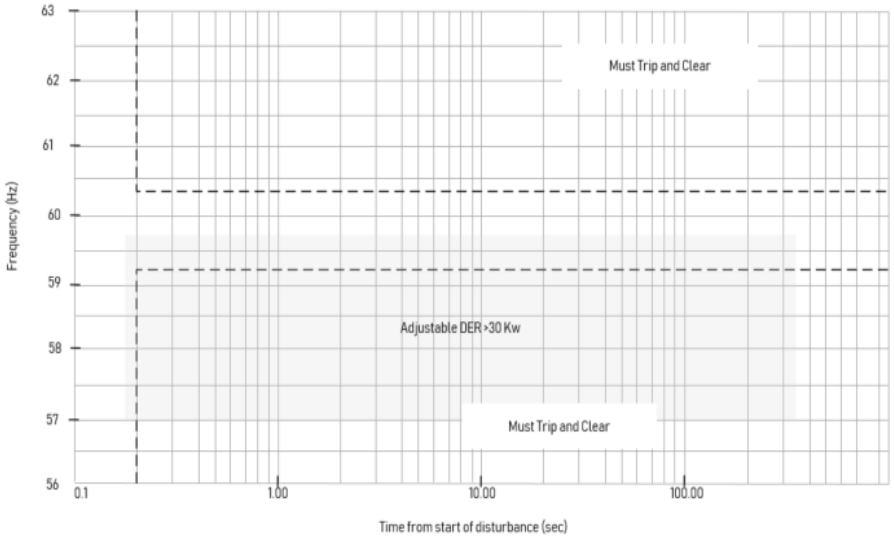


State Definitions

State	
S0 On Grid PCC Breaker Closed	PCC breaker is closed, BESS, PV and generator is in grid following mode.
S1 Off Grid- BESS Only	MGC Configures the BESS in droop Mode.MGC's responsibility is to maintain a pre-defined spinning reserve on the island. MGC configures the frequency / volt droop curves on the BESS . The BESS frequency / voltage shall decrease as the load increases. If the MGC is unable to maintain the incremental spinning reserve then MGC will request the generator to start. The MGC may also request the generator to start when the BESS reaches low SOC's.
S2 Off Grid- BESS + PV	MGC Configures the BESS in droop Mode. MGC's responsibility is to maintain a pre-defined spinning reserve on the island. In addition the MGC also curtails the PV output under high SOC conditions. PV output is curtailed using the freq-wat function in the PV inverters. The nominal droop curve on the BESS is increased, which causes the BESS to increase the system frequency at high SOC's . The increased frequency causes the PV inverters to curtail as per the slope defined in the freq-watt curve.
S3 Off Grid- BESS + PV+GEN	MGC Configures the BESS in droop Mode. MGC's responsibility is to maintain the incremental spinning reserve on the island. In addition the MGC also curtails the PV output under high SOC conditions. MGC Starts the generator when the incremental spinning reserves cannot be met. The power sharing is managed by adjusting the droop curves. MGC also curtails PV power in case of generator reverse power conditions. To charge the BESS , MGC decreases the frequency setpoint while increasing the setpoint point on the generators.
S4 Off Grid- BESS +GEN	MGC Configures the BESS in droop Mode. MGC Starts the generator when there incremental spinning reserves cannot be met. The power sharing is managed by adjusting the droop curves.
S5 Off Grid- Black Out	MGC transitions the power system into a black out state when the BESS is at Low SOC and PV & Generators are unavailable to charge the BESS.

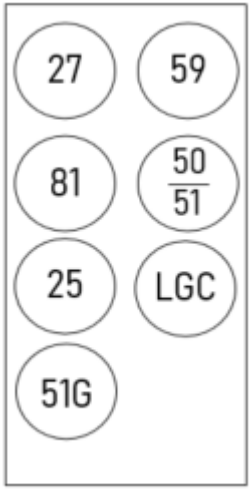
Ride through requirements -IEEE Standard 1547



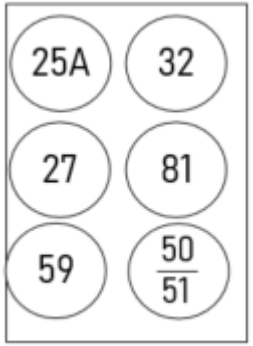


Overview of Microgrid protection

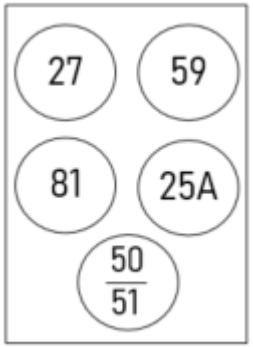
PCC Intertie protection



Generator Protection



Inverter Protection



Conclusion and Future work

- Minimalistic low cost control strategy
- Maximize the renewable energy asset
- Protection and control strategy for multi asset microgrids
- Proper load management can avoid oversize of DER
- 81RF not reliable to capture all corner cases.
- Faster communication such as IEC 61850 should be considered for peer-peer communication