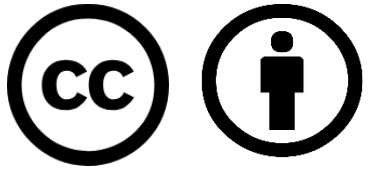
Shipboard Power System as a Microgrid

Shipboard Power System Fundamentals

Revision of 20 December 2025

Dr. Norbert Doerry



http://doerry.org/norbert/MarineElectricalPowerSystems/index.htm

Essential Questions

What is a microgrid?	Remember
What are the implications of a limited inertia system?	Understand
What are the implications of a limited generation capacity?	Understand
What are the implications of interconnecting with the terrestrial power system?	Understand

Microgrid Definition

- IEEE Std 2030.7 defines a microgrid as:
  "A group of interconnected loads and distributed energy resources with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid-connected or island modes."
- Distributed energy resources (DER) are further defined as:
  "Sources and groups of sources of electric power that are not directly connected to the bulk power system; they include both generators and energy storage technologies capable of exporting power."
- Modes
  - When a microgrid is electrically connected to the grid it is in the "Steady state connected" mode.
  - When a microgrid is operating disconnected from the grid it is in the "Steady state islanded" mode.
  - Transition modes include "Unplanned islanding", "Planned islanding", "Black start", and "Reconnect."

Shipboard power systems as a microgrid

- Not a perfect fit
  - Not all ships can connect to the grid.
  - Some ships can connect to the grid and receive power from the grid, but cannot operate generator sets in parallel with the grid.
  - Even ships that can operate generator sets in parallel with the grid typically only do so for short periods of time.
- Ships at sea are equivalent to a microgrid operating in “steady state islanded” mode.
- DERs onboard ship are typically gas turbine generator sets or diesel generator sets

Limited inertia systems

- Within the context of a power system, inertia is …
  - The amount of stored energy that can be rapidly applied to maintain voltage and frequency due to transients from changing loads
- Sources of inertia
  - Generator sets
    - Rotational mechanical inertia of the rotor
  - Power electronic converters
    - Stored electrical energy in dc link capacitance
- Terrestrial Grid is considered an infinite bus with infinite inertia
  - Changes in loads result in only local transient responses
- Microgrids and shipboard power systems in islanded mode have limited inertia.
  - Changes in load results in system voltage and frequency transients.
  - Can lead to power quality issues or even generator sets dropping offline if not controlled properly.

Limited Generation Capacity

- Terrestrial Power Systems
  - Real Power is scheduled
  - Reactive Power is a function of network topology
- Islanded microgrids and shipboard power systems
  - Requires active control methods to balance supply and consumption of real and reactive power when generator sets are paralleled.
    - Real Power is shared via either frequency droop or control signals (either analog or digital)
    - Reactive power is shared via either voltage droop or control signals (either analog or digital)
  - Energy storage may be employed to augment generation when needed.
  - Load management may be employed if online generation capacity is less than the online load.
    - Typically implemented as load shedding

Interconnecting with the Terrestrial Grid

- Terrestrial microgrids
  - DER operation and grid operation are integrated when in the steady state connected mode.
- Shipboard power systems
  - Rarely operate for extended periods of time with shipboard generator sets paralleled with the terrestrial grid.
  - Many ships will “break before make” such that the transfer to shore-power does not involve the paralleling of generator sets with the grid.
  - Those ships that can operate paralleled to the grid usually only do so during the transfer of load to and from shore-power. (make before break)