# Shipboard Power System vs Terrestrial Power Systems

## Shipboard Power System Fundamentals

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

# Essential Questions

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| What are the implications of differences in power management and system control techniques? | Understand |
| What are the implications of differences in fault management techniques? | Understand |
| What are the implications of differences in cable lengths? | Understand |
| What are the implications of differences in load management techniques? | Understand |

# Differences between Shipboard Power Systems and Terrestrial Power Systems

- Non-constant frequency
- Lack of time scale separation
- Load sharing instead of power scheduling
- Short electrical distances
- Load dynamics
- Tighter control
- Ungrounded or high-impedance grounded systems
- Physical environment

# Power management and system control

- Terrestrial power systems
  - System has “infinite” inertia.
    - Frequency and voltage controlled to very close tolerances
  - Generator sets scheduled with respect to power provided.
  - Voltage setpoints set to keep voltages and reactive power within bounds.
  - Some transformers have tap changers which can be used to keep voltages within bounds.
  - System power factor can be managed with capacitors and static VAR compensators.
  - Determining which generators to have online is based on ongoing optimization calculations
  - Bringing online a new generator can take hours
- Shipboard power systems
  - System has limited inertia.
  - Select loads may be a significant fraction of online generator set capacity.
    - Can cause significant voltage and frequency transients
  - Using droop to share real and reactive power can result in the frequency and voltage deviating from nominal values.
  - Optimal line-ups of generator sets determined during design
  - Bringing online a new generator can take seconds to minutes

# Fault management

- Terrestrial Power Systems
  - Solidly grounded
    - Line to line and line to ground faults result in large currents used with coordinated breakers to clear faults
  - Many faults are self clearing
    - Automatic attempt to reclose after a few seconds
  - Long cables limit fault current
- Shipboard Power Systems
  - High Impedance or ungrounded
    - Line to line faults result in large currents used with coordinated brakers to clear faults
    - Continued operation with single line to ground faults
  - Most faults are not self clearing
  - Short cables result in high fault currents
    - Nominal system voltage often based on matching available fault current from generators with fault interruption capability of circuit breakers.
    - Rating of medium voltage to low voltage transformers may be limited based on fault current.

# Cable lengths

- Terrestrial Power Systems
  - For many analyses, generator sets are assumed to be in parallel with an infinite grid via the impedance of a long cable
- Shipboard Power Systems
  - Smaller impedance of shorter cables results in tighter coupling of the dynamics of paralleled generator sets
    - Analyses should account for the coupling among all paralleled generators
    - Large power fluctuations among the paralleled generators can occur during transients.
      - May be large enough to trip generator sets offline

# Load management

- Terrestrial Power Systems
  - Large number of generator sets online
    - Loss of any one does not impact ability of system to serve all loads
- Shipboard Power Systems
  - Only a few generator sets online
    - Loss of any one may impact ability of system to serve all loads
  - Relies on load shedding to keep the total load less than online generation capacity.
  - Large loads should coordinate with power management system before making a large change in load.
    - Examples include propulsion motors, and large ventilation fans