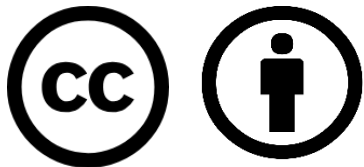


Shipboard Power System vs Terrestrial Power Systems

Shipboard Power System Fundamentals

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

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Essential Questions

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 breakers 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