Shipboard Power System Characteristics

Shipboard Power System Fundamentals

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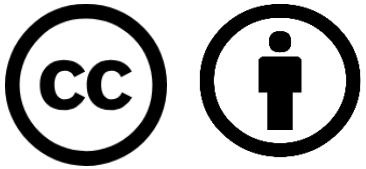

Essential Questions

What is electrical power used for onboard ship?	Understand
What are the implications of a need for high power reliability / Quality of Service?	Understand
What are the implications of a need for survivable power systems?	Understand
What are the implications of the marine environment?	Understand

Uses of electrical power onboard ship

- IEEE Std 45.1
  - 100 Propulsion
  - 200 Batteries and battery chargers
  - 300 Power conversion equipment
  - 400 Lighting
  - 500 Electronics
  - 600 Navigation systems
  - 700 Auxiliaries
  - 800 Heating ventilation and air conditioning systems
  - 900 Deck machinery
  - 1000 Food services
  - 1100 Workshops/Laundry equipment
- MIL-STD-881
  - 100 Hull structure
  - 200 Propulsion plant
  - 300 Electric plant
  - 400 Command, communications, and surveillance
  - 500 Auxiliary systems
  - 600 Outfit and furnishings
  - 700 Armament

A ship is a floating city

Power Quality – Quality of Service

- Power Quality
  - Power consistently adheres to interface standard
    - MIL-STD-1399 section 300 part 1 (LVAC)
    - MIL-STD-1399 section 300 part 2 (MVAC)
    - IEEE Std 45.1 (all)
  - Measured at the interface between power system and loads
    - Similar to the point of common-coupling in terrestrial power systems
- Quality of Service
  - Mean time between service interruption (MTBSI)
  - A service interruption is a power interruption that lasts longer than a load can tolerate
    - Reconfiguration time (t1) is the maximum time to reconfigure the distribution system in response to a fault without bringing on additional generation capacity.
      - Function of technology used in circuit protection devices.
    - Generator start time (t2) is the maximum time to bring the slowest generator set (that can act as a standby generator set) online.
  - Loads categorized by tolerance to power interruptions
    - Uninterruptible – cannot tolerate power interruptions of duration t1.
    - Short term interrupt – can tolerate power interruptions of duration t1, cannot tolerate power interruptions of duration t2.
    - Long term interrupt – can tolerate power interruptions of duration t2.

Characteristics of shipboard power systems (As compared to terrestrial systems)

- Frequency is not a constant
- Lack of time scale separation
- Load sharing instead of power scheduling
- Short electrical distances
- Load dynamics may be important
- Tighter control
- Ungrounded or high-resistance grounded systems
- Physical environment

Survivability

- Threats
  - Collision
  - Flooding
  - Fire
  - Cyber attack
  - Weapons detonation (naval ships only)
- Susceptibility
  - Likelihood that the electrical power system will be exposed to a threat
- Vulnerability
  - How well the electrical power system maintains power quality and power continuity following exposure to a threat
- Recoverability
  - How quickly electrical power can be restored following an outage caused by a threat.

Survivability requirements

- Commercial ships
  - Regulations (law)
  - International Treaties such as SOLAS
  - Classification Societies (such as ABS, DNV, LR)
- Complex ships – Zonal Design
  - Ship is divided into multiple zones
    - Zone boundaries align with the hull and watertight subdivision bulkheads
    - Same zone boundaries apply to all distributed systems.
  - Zonal Survivability
    - Damage to one or two adjacent zones does not result in a service interruption in undamaged zones. (May only apply to mission critical equipment)
    - Addresses Vulnerability
  - Compartment Survivability
    - Power can be quickly restored to mission critical equipment in a damaged zone if it is same to do so.
    - Addresses Recoverability
    - May incorporate a casualty power system

Marine Environment

- Characteristics
  - Ship motions (roll, pitch, slam, list, trim, etc.)
  - Atmosphere (extreme temperature variation, high salt, high humidity)
  - Vibration
  - Damaging fumes or vapors
  - Abrasive particles
  - Salt spray
  - Ice
  - Sunlight
  - Shock and blast (naval ships)
- Standards
  - IEEE Std. 45.1
  - MIL-DTL-917 Basic Requirements
  - MIL-DTL-901 Shock Tests
  - MIL-STD-167-1 Mechanical Vibrations
  - MIL-STD-1399-301 Ship Motion and Attitude
  - MIL-STD-1399-302 Weather Environment