EMC Plan for Power Drive Systems – Prevent Interference with Others

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About the presenter

Oskari Leppäaho is a Development Engineer, Main Circuit for Danfoss Drives and Power Electronics in Vaasa, Finland

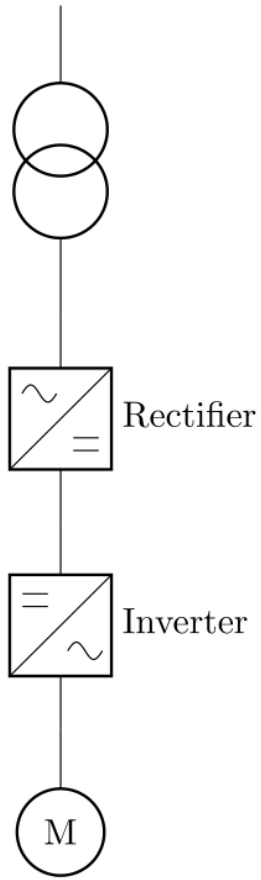
- PhD. INSA Rennes, France (2023). EU Horizon 2020, PETER project

Focus areas:

- Electric Power Drives, Inverters and Converters from 1 kW to 10 MW
- Systems Engineering, Software and Hardware Integration
- EMC

Background – Power Drive System (PDS)

- PDSs transform grid voltage/frequency into a more usable form for electric motors and other equipment
  - Low (230-690 V) to medium (2.4 kV – 25 kV) voltage
  - Typical power range is from kilowatts to megawatts
    - Focus of this presentation is on low voltage and megawatt power
- PDSs are commonly the main electrical energy consumers behind a feeding transformer
  - In closed systems, they could be the main producers, too!
- Energy savings and process control performance are main selling points



Where are the MW scale PDSs used?

Some fun!

Heavy Industry

Geothermal Energy Production

Mining Operations

Propulsion & Power Generation

Emissions or Immunity?

- Emissions
  - Switching of high voltage with fast speed (nanosecond-scale) is bound to generate a rich frequency spectrum
    - Mantra: “Energy efficiency first, EMC second”
    - There is no better way of operation known currently
- Immunity of control systems
  - Low-level control systems have largest challenges with self-compatibility
  - Higher level control systems can be susceptible to external disturbances
  - Some products are used in functional safety related systems
    - Cut power to half of the factory vs. Safe Torque Off (STO) of one machine under maintenance
- This presentation concentrates on emission aspects

Motivation for EMC plan

- Filters for MW-scale drive systems are bulky and expensive
  - Rule of thumb: cost equal to the drive cost
  - 3-level inverters, SiC & GaN power semiconductors help with filter cost
    - For now, just the cost balance is different
- Benefits from filtering are often contradicted
  - Arc furnaces
  - Old drive installations
  - Welding machines
- It is better to concentrate on the plant
  - Not a single installation

Rule-based vs. Risk-based EMC

- Rule-based approach
  - Every product complies with standard requirements for the installation
  - Result: Multiple bulky and expensive filters in the system
- Risk-based approach
  - Not all products/systems comply with the traditional requirements
  - System-level mitigation measures in use
    - Complete installation complies with the standard requirements
  - Result: Usage of filters only in optimum locations to minimize cost
    - IEC 61800-3:2022: “the user of the components should have a free decision from the economical point of view … to achieve electromagnetic compatibility”

EMC plan – IEC 61800-3

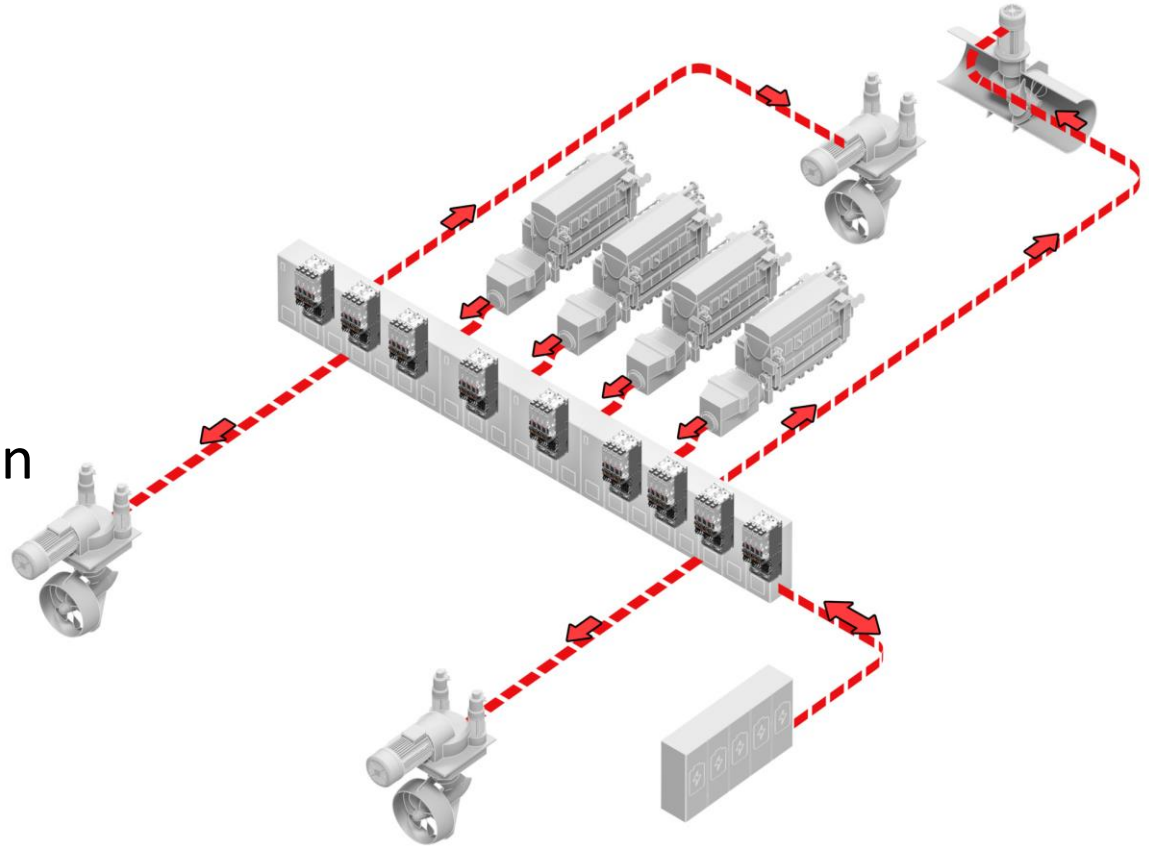
- C4 class of IEC 61800-3 provides manufacturers a possibility to supply devices with unlimited high frequency emissions
- This class of devices needs coordination between installers and manufacturers
  - Annex E provides guidance on this topic
  - In practice, project-based EMC engineering is required to ensure compliance
- Isolated terra (IT) supply systems are one large area
  - They need to tolerate one ground fault
    - Due to economical reasons or functional safety (e.g. special pumps)
    - Capacitance to ground is limited => difficulties in implementing CM filtering
      - Isolation transformer is practically the only option => Expensive

System level considerations

- Is there a separate transformer supply?
  - Find out the HF characteristics of the transformer
  - “Free” filtering
- Stray-capacitance & inductance of the supply lines
  - “Free” filtering
  - Beware of resonances & transmission-line effects
- Separate machine room
  - Metallic doors for fire safety => 99 % of time closed
  - Find out the shielding effectiveness of the room
- Distance from victim equipment
  - Zoning between industrial, commercial & residential areas
  - Conducted emissions attenuate by radiating to the environment + skin effect
  - Radiated emissions attenuate by: min. 60 dB / km

Case – Marine Propulsion

- Electric main propulsion: 5 MW
  - Zone: Special power distribution
  - EMC filtering
    - Minimal
    - Typically, in a Faraday cage (engine room)
- Hotel load: 100 kW
  - Branched from special power distribution
  - Zone: General power distribution
  - EMC filtering
    - Transformer to cut common mode
    - LC differential mode filtering



Conclusion – EMC plan for PDS

Advantages

- Cost-effective solutions
- Size and weight gains
  - Especially important for mobile systems
- Possibility for better compatibility margins
  - EMC design by expert

  vs. blindly following EMC rules
  - Chef vs. cookbook

Disadvantages

- EMC expert involvement needed
  - Need knowledge on EMC & whole installation
  - Availability of experts?
- Amount of planning increases
  - Management plan
  - Control plan
  - Implementation plan
  - Verification plan

Thank you!
Questions?

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