
CERN

Advanced Power-Quality Technologies for Future Circular Collider (FCC)

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Advanced Power-Quality Technologies for Future Circular Collider (FCC)

- Introduction to Power Quality
- Transient Voltage Dips
- Dynamic Voltage Restorer
- Back-to-Back HVDC Link
- DC Distribution Grid
- Comparison and Conclusions

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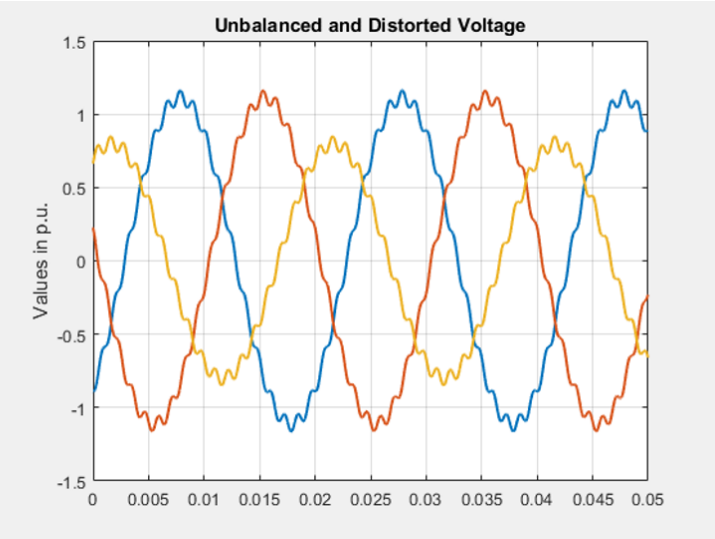
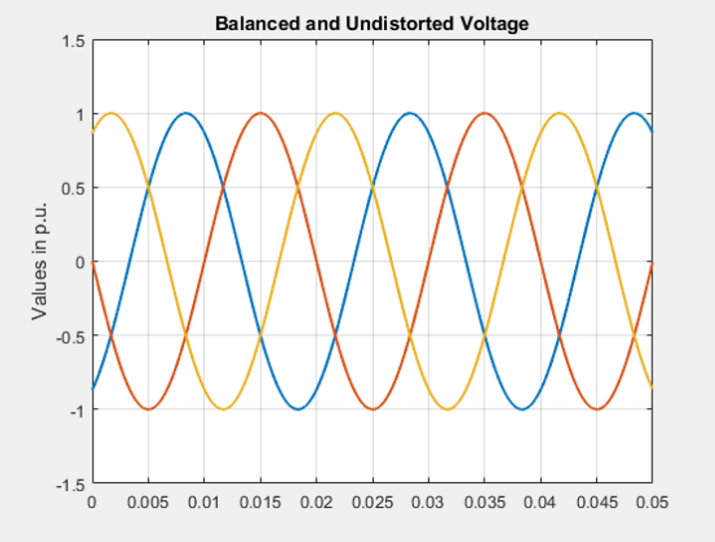
Power Quality for FCC

Introduction to Power Quality

- FCC demands for an excellent power grid





- Harmonic filtering
- Voltage support/reactive power compensation
- Transient voltage dip mitigation

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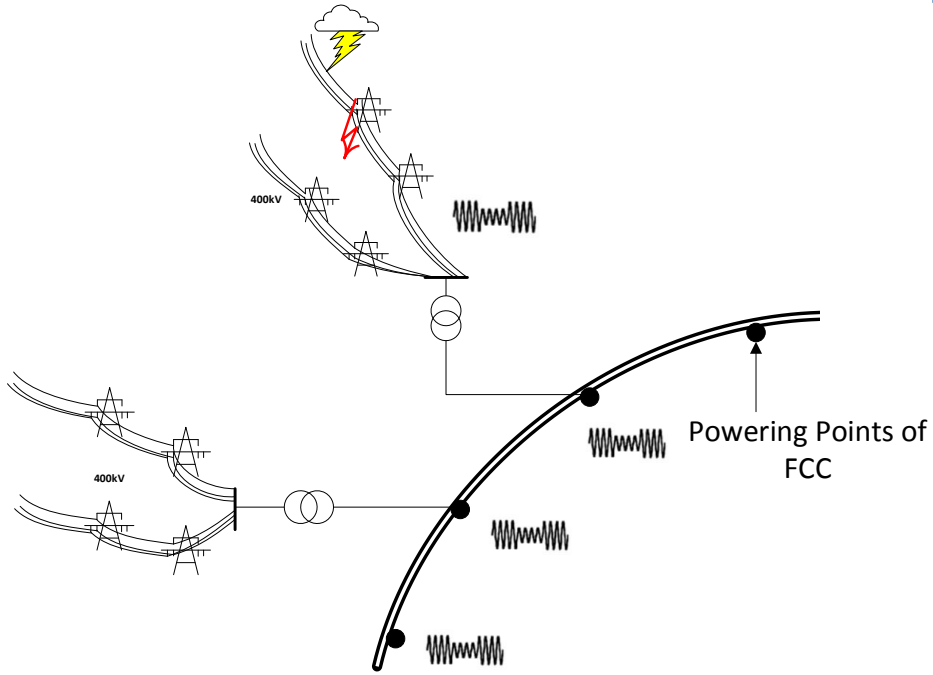
Main Cause and Numbers

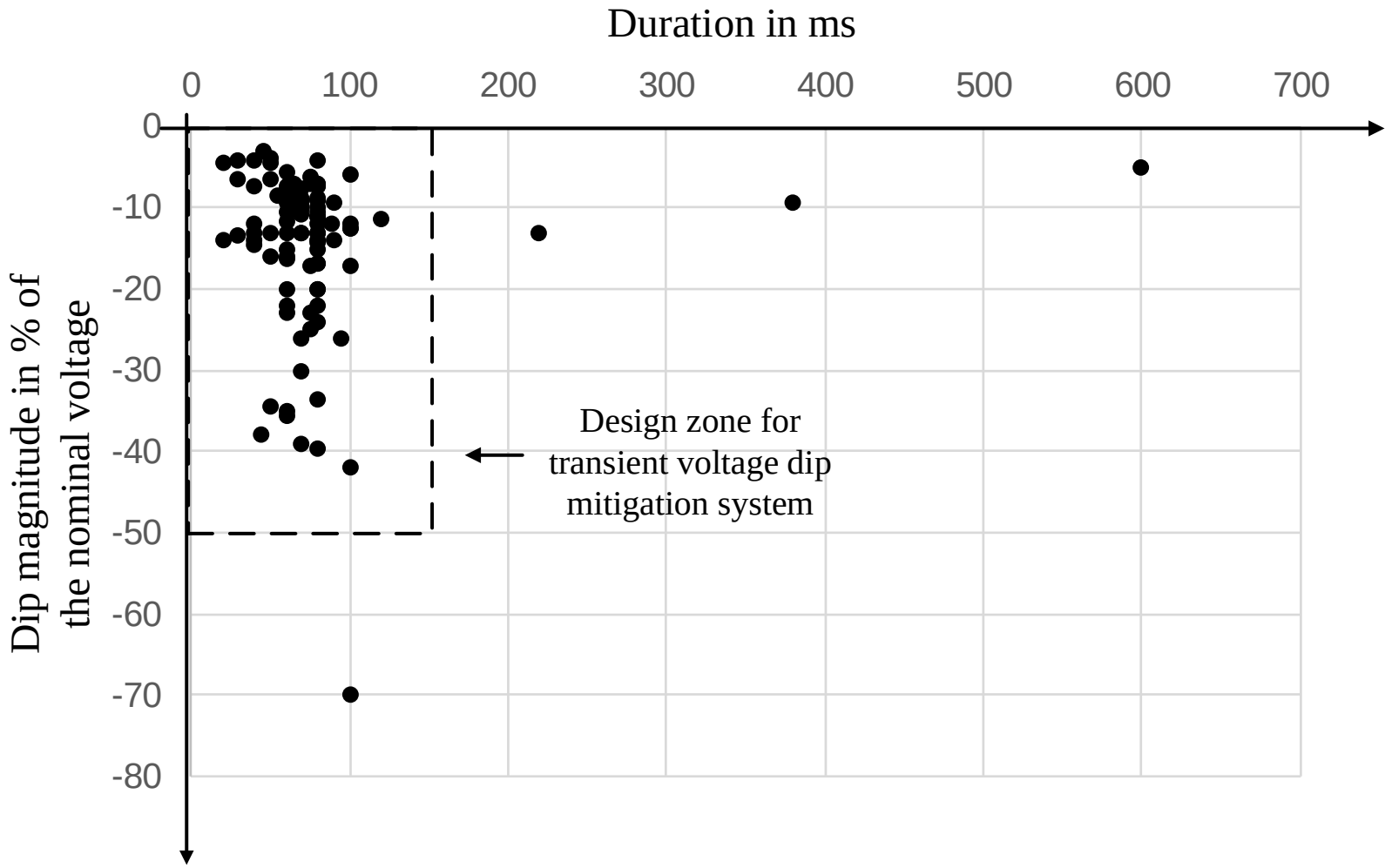
Transient Voltage Dips

- Lightning strike in the 400kV overhead lines
- At CERN now: 20-40 events per year
- For FCC expected number of: 100-200 events per year



Statistics

Transient Voltage Dips

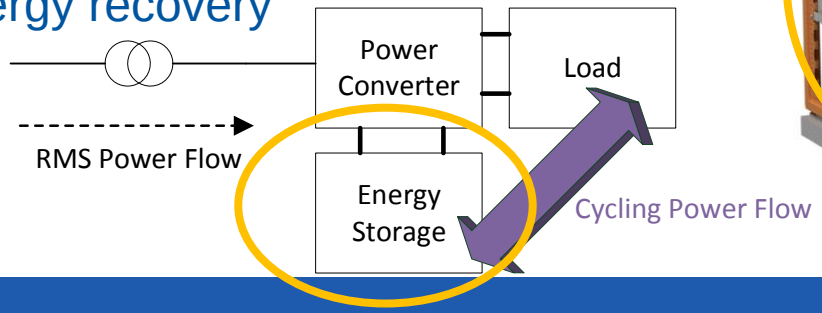


Mitigation at Equipment-Level

Transient Voltage Dips

- Example: SIRIUS Power Converter
- Higher cost and complexity per unit
- Each equipment unit has to be upgraded

Synergy for cycling operations: energy recovery



Mitigation at System-Level

Transient Voltage Dips

- Provides the immunity of transient voltage dips for the complete FCC distribution grid
- Release pressure when designing equipment
- Three solutions are under study

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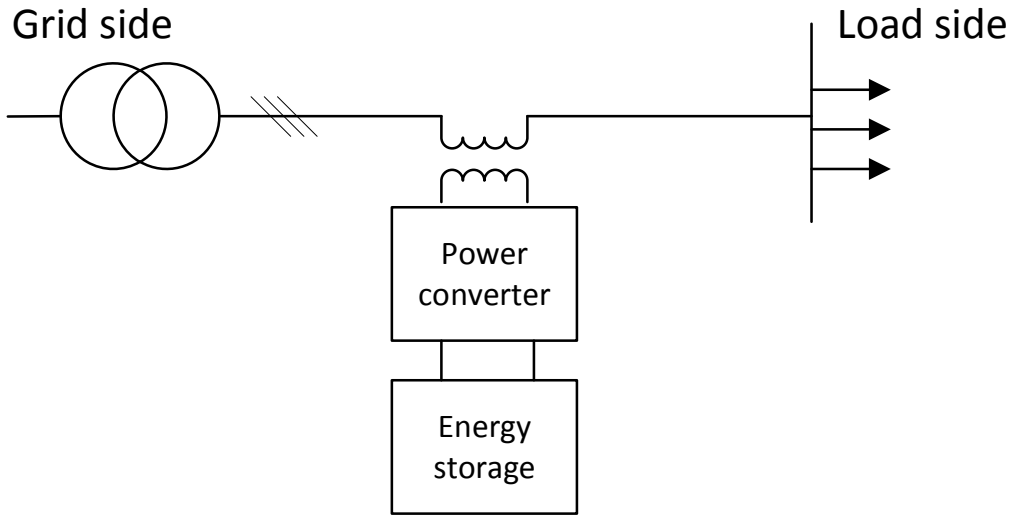
Main Features

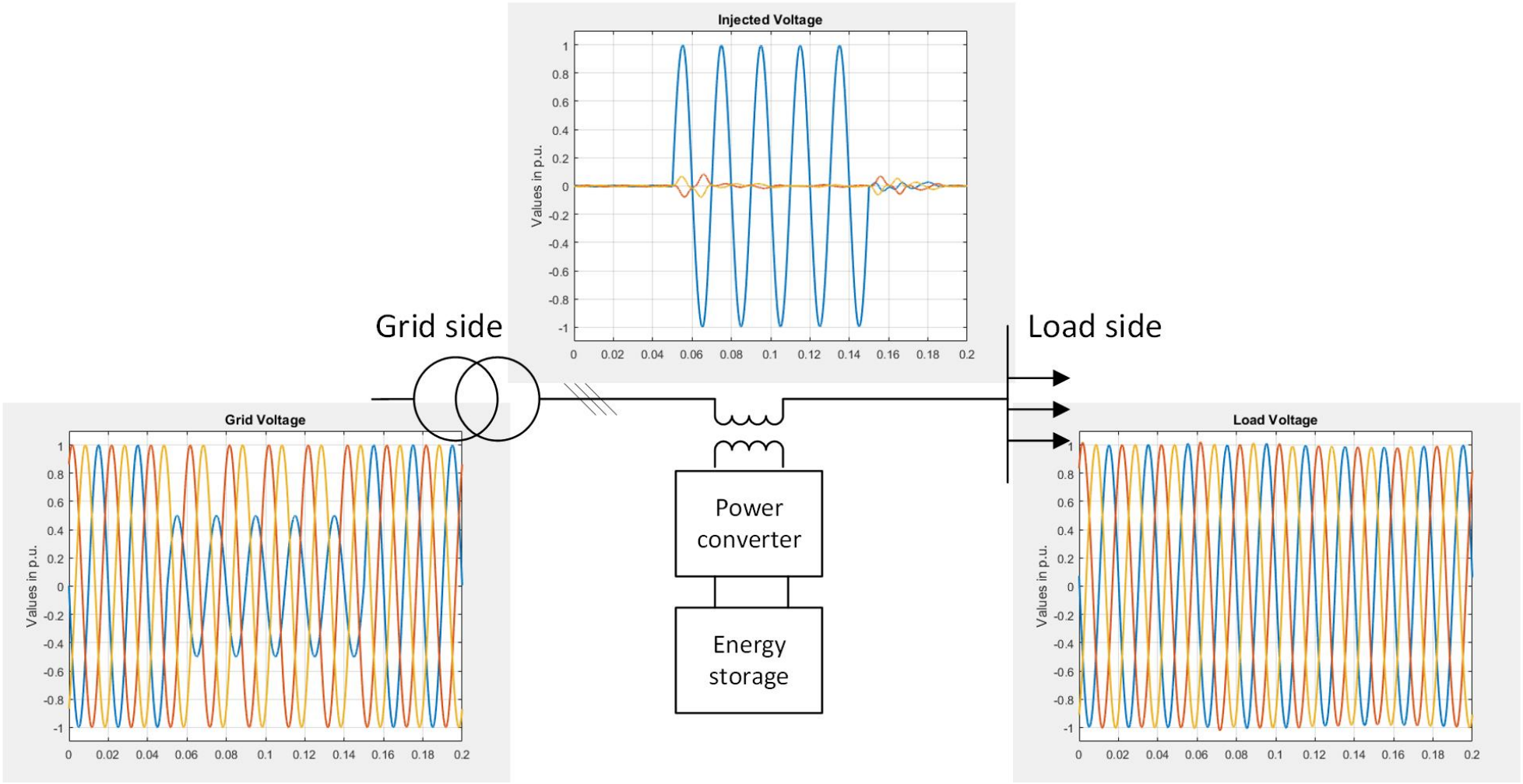
Dynamic Voltage Restorer

- Economical: series injection of the Δu
- Reaction time < 1ms
- Already used for critical production processes



Operational Principle

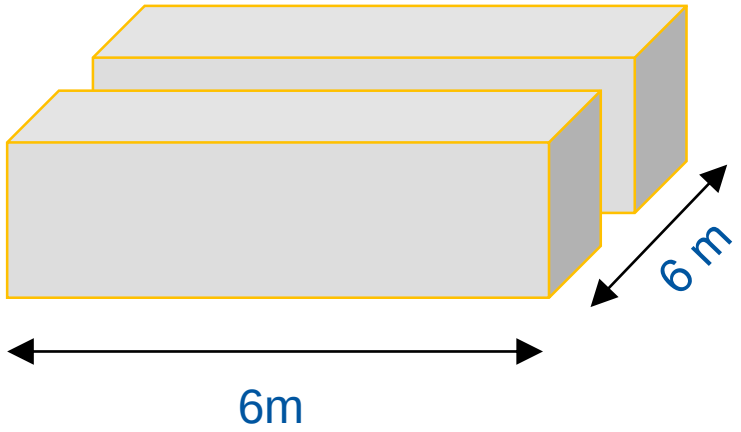
Dynamic Voltage Restorer

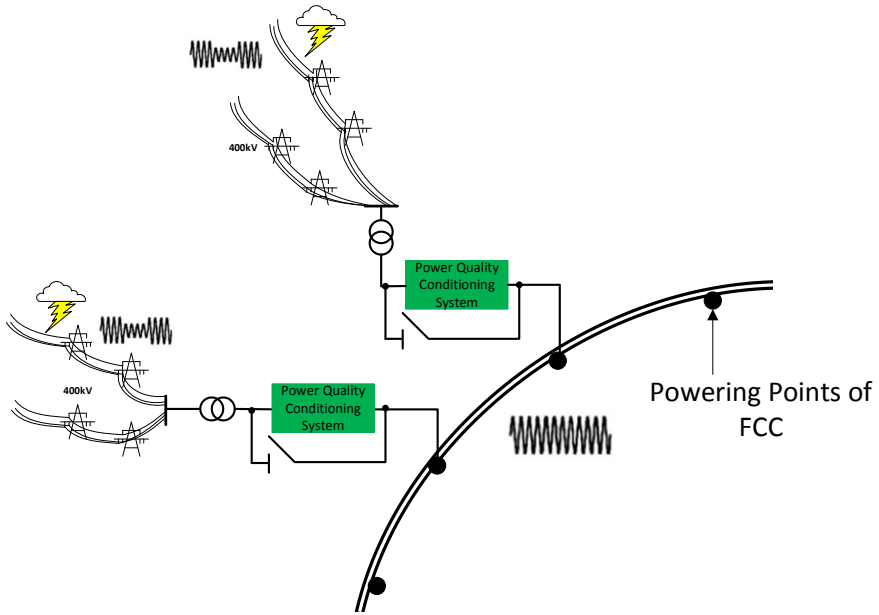


Applied for FCC

Dynamic Voltage Restorer

- Is integrated in classical AC distribution grid
  - By-pass switch for downstream selectivity of the protection system
- Several voltage levels are possible
- Size to supply a 50MVA load:





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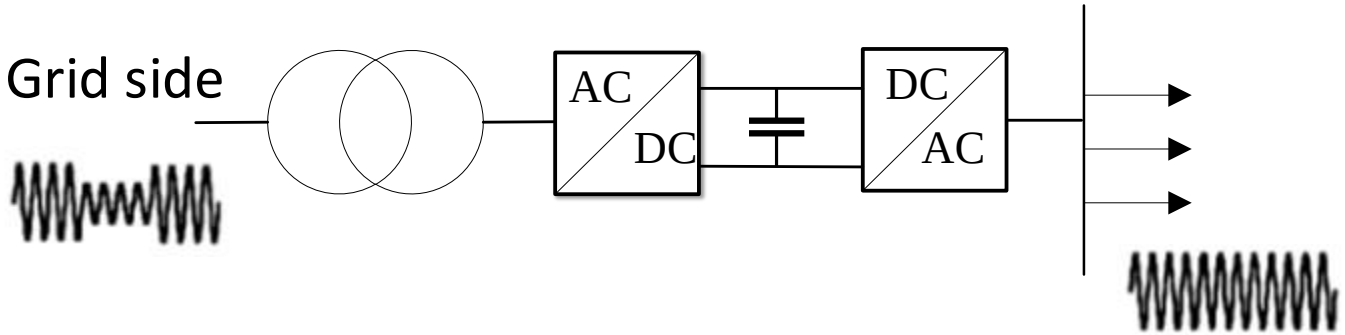
Main Features

Back-to-Back HVDC Link

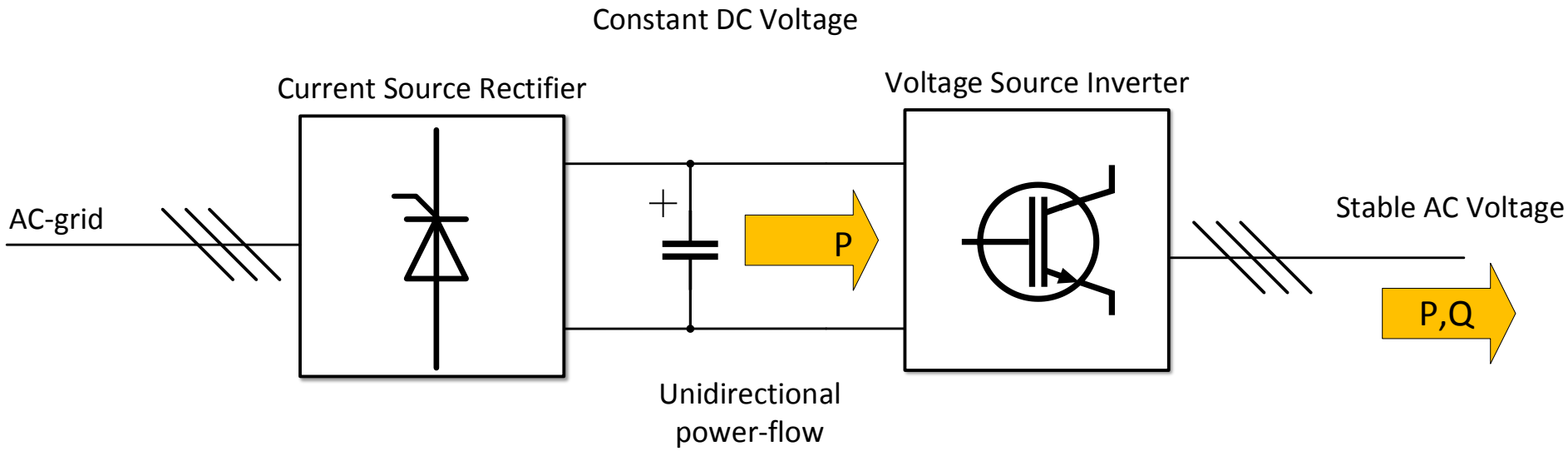
- Used for DC power transmission
- Decoupling from the supplying grid
- Protected from external disturbances
- Provide reactive power at the load side



System Design Considerations

Back-to-Back HVDC Link

- Rectifier design
- DC link design
- Inverter design
- For example: hybrid solution



Applied for FCC

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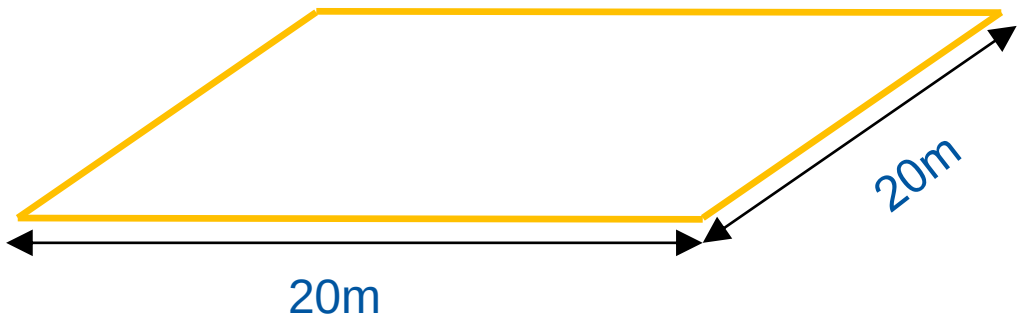

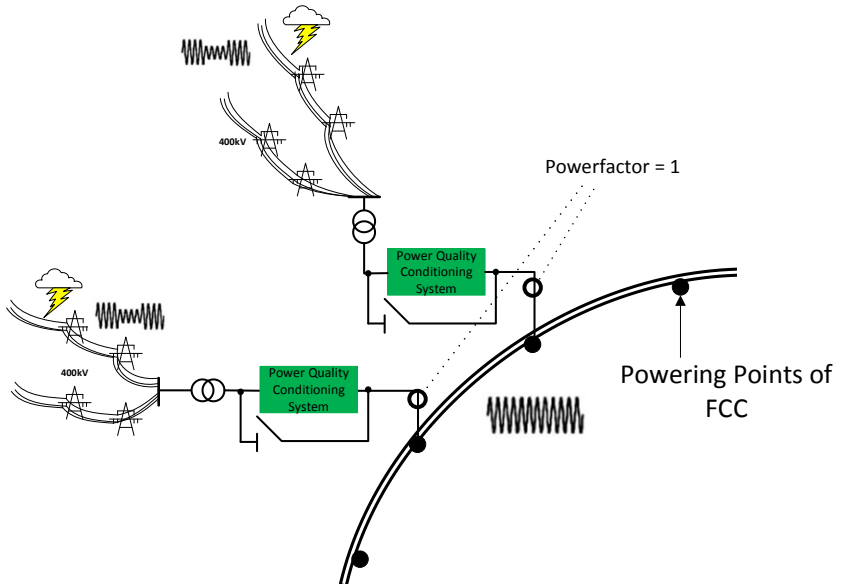

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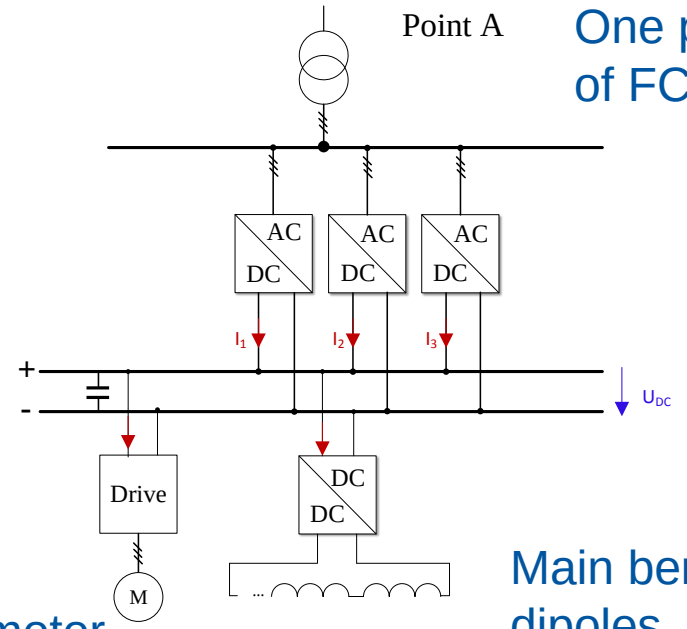
Main Features

DC Distribution Grid

- No electro magnetic interference
- Higher power transmission capability
- Efficient large scale energy recovery



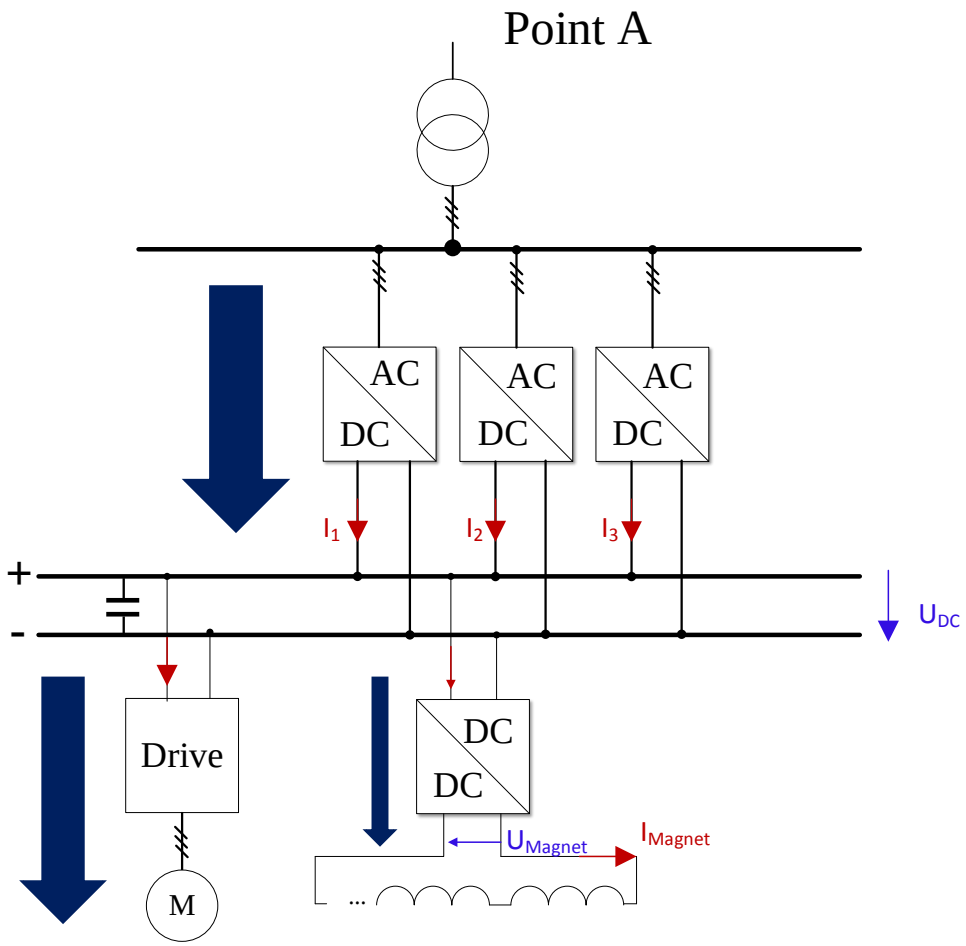
One powering point of FCC

Compressor motor

Main bending dipoles

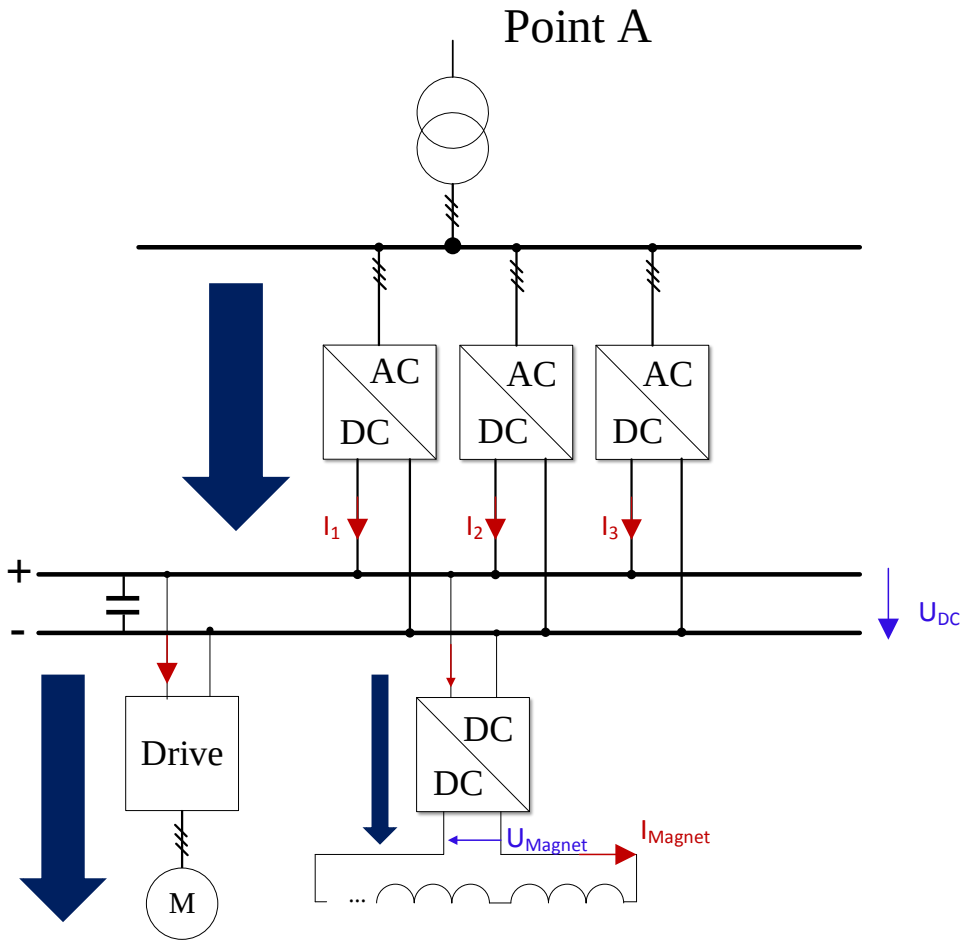
Energy Recovery

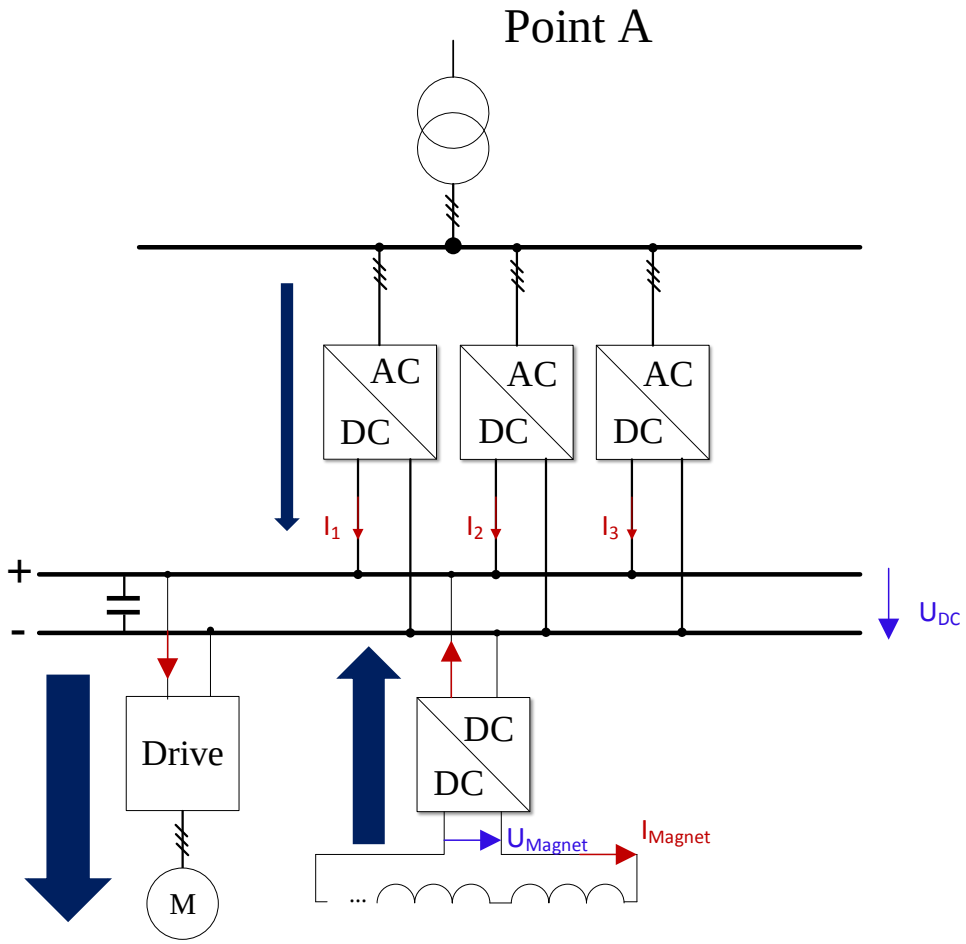
DC Distribution Grid



Energy Recovery

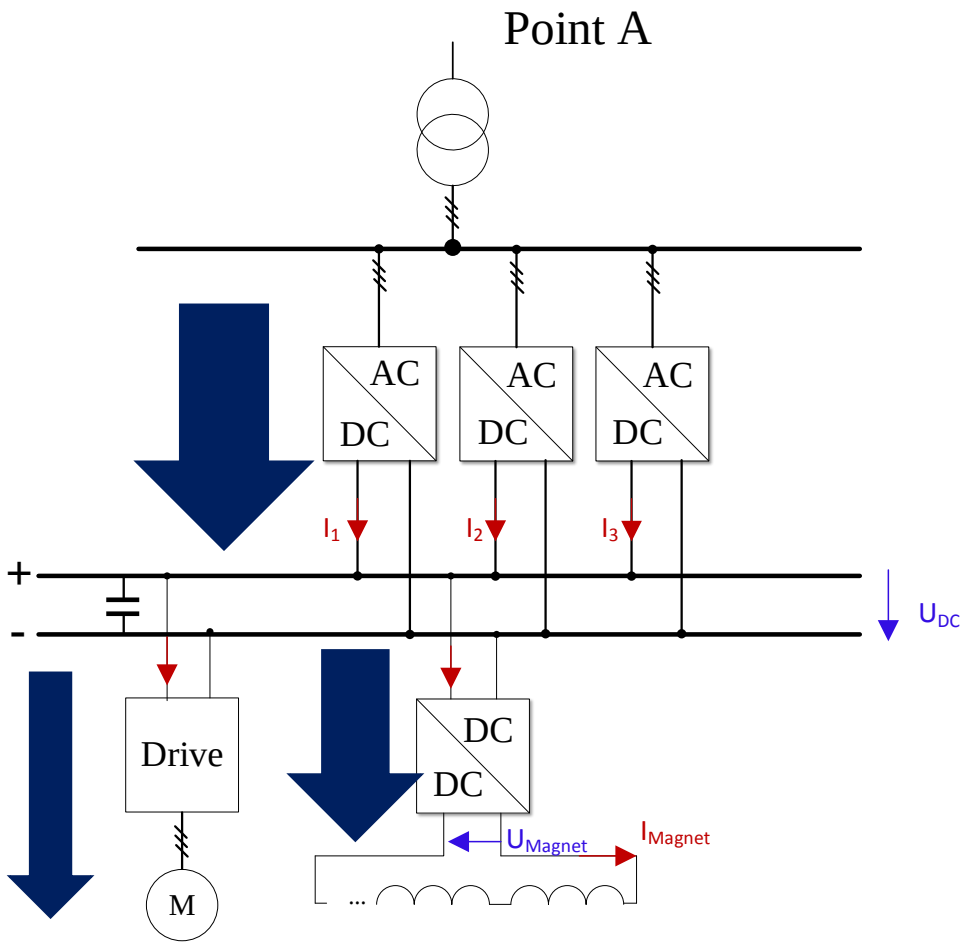
DC Distribution Grid





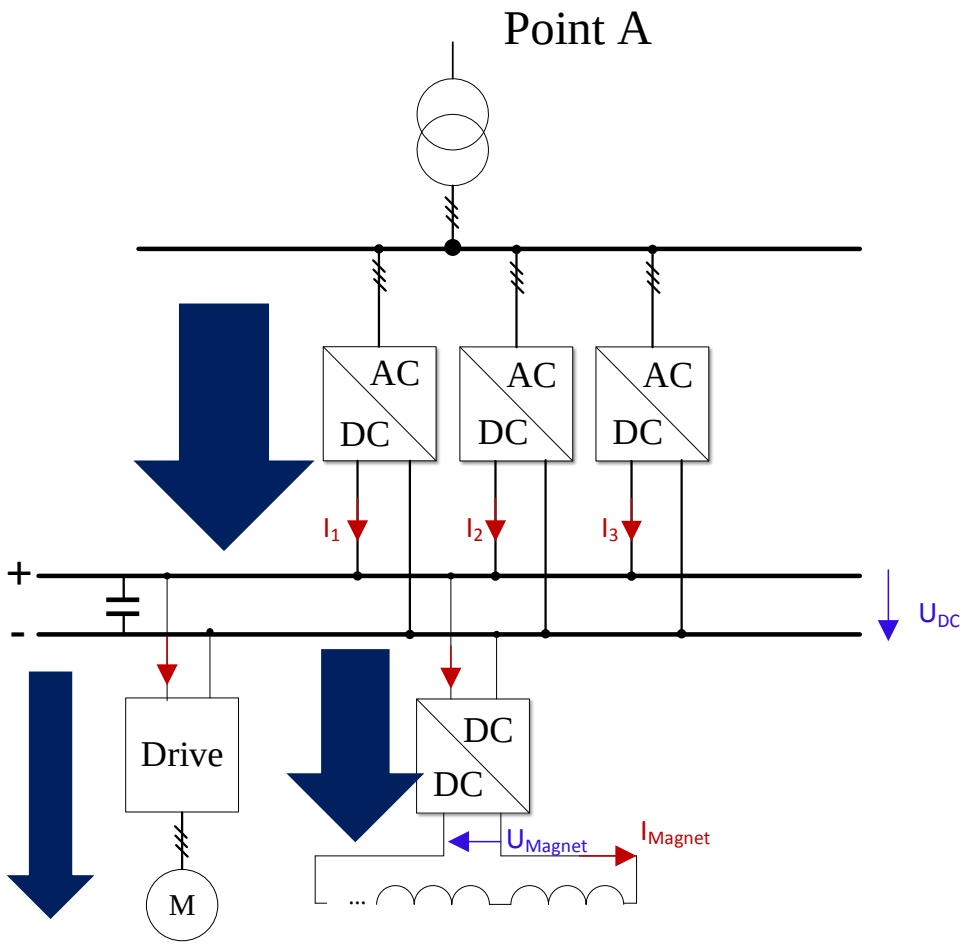
Energy Recovery

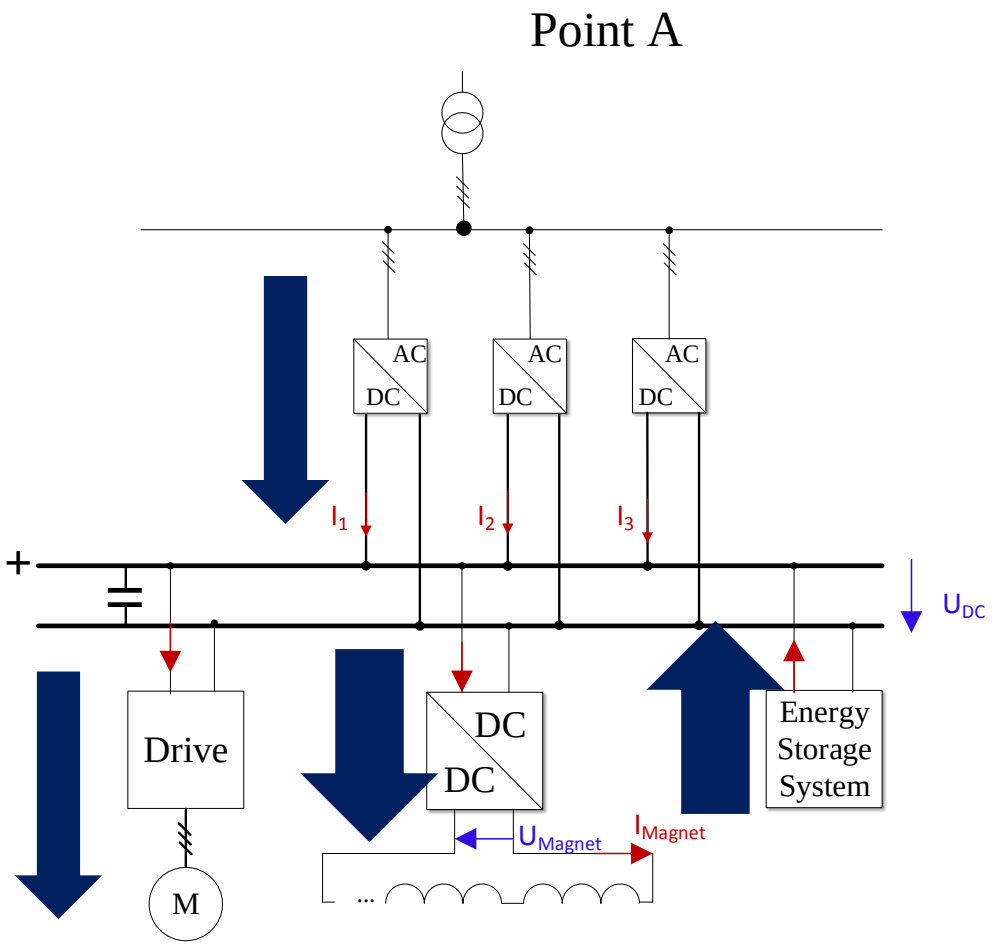
DC Distribution Grid



Energy Recovery

DC Distribution Grid





Energy Recovery

DC Distribution Grid

See dedicated talk from **Francisco R. Blanquez** in session:
Special Technologies: Machine protection, circuit and powering Thursday 16:30-16:50

R&D Aspects

DC Distribution Grid

- Isolation
- Optimal DC voltage level

- Protection system
  - Selectivity
  - Short circuit detection and current breaking
- Redundancy

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Comparison and Conclusions

	Dynamic Voltage Restorer	Back-to-Back HVDC Link	DC Distribution Grid
Transient Voltage Dips	covered	covered	covered
Compensation of Pulsating Reactive Power (load side)	Not covered	covered	covered
Compensation of Pulsating Active Power (load side)	Not covered	covered	covered
Stand-by losses	Very Low	High	Medium
Technology Readiness Level	Available in industry	Available in industry	Design and standardisation phase
Protection Aspects	Bypass is needed	Bypass is needed	In development

Comparison and Conclusions

- Power quality is a key aspect
- High number of transient voltage dips expected for FCC
- Three potential solutions
  - Different features
  - Different impacts on the whole FCC distribution network
- For the technical design phase
  - More studies in detail
  - One option has to be chosen


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