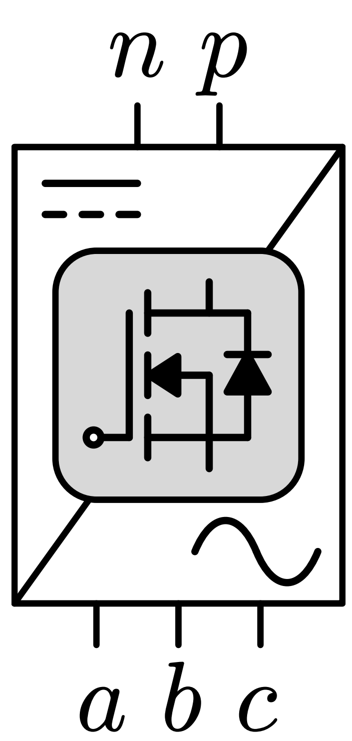
From simulation to implementation:
Validating interconnected inverter-based resources in smart grids using controller hardware-in-the-loop.

Most renewable electricity devices use inverters

- Renewable generation
  - Solar PV systems
  - Type 3 & 4 wind turbines
- Sustainable loads
  - Bidirectional EV chargers
  - Heat pump compressors
- Energy storage systems
  - Batteries
  - Supercapacitors
  - Hydrogen fuel cells
  - High speed flywheels



Two perspectives: power electronics and power systems

Power electronic design:

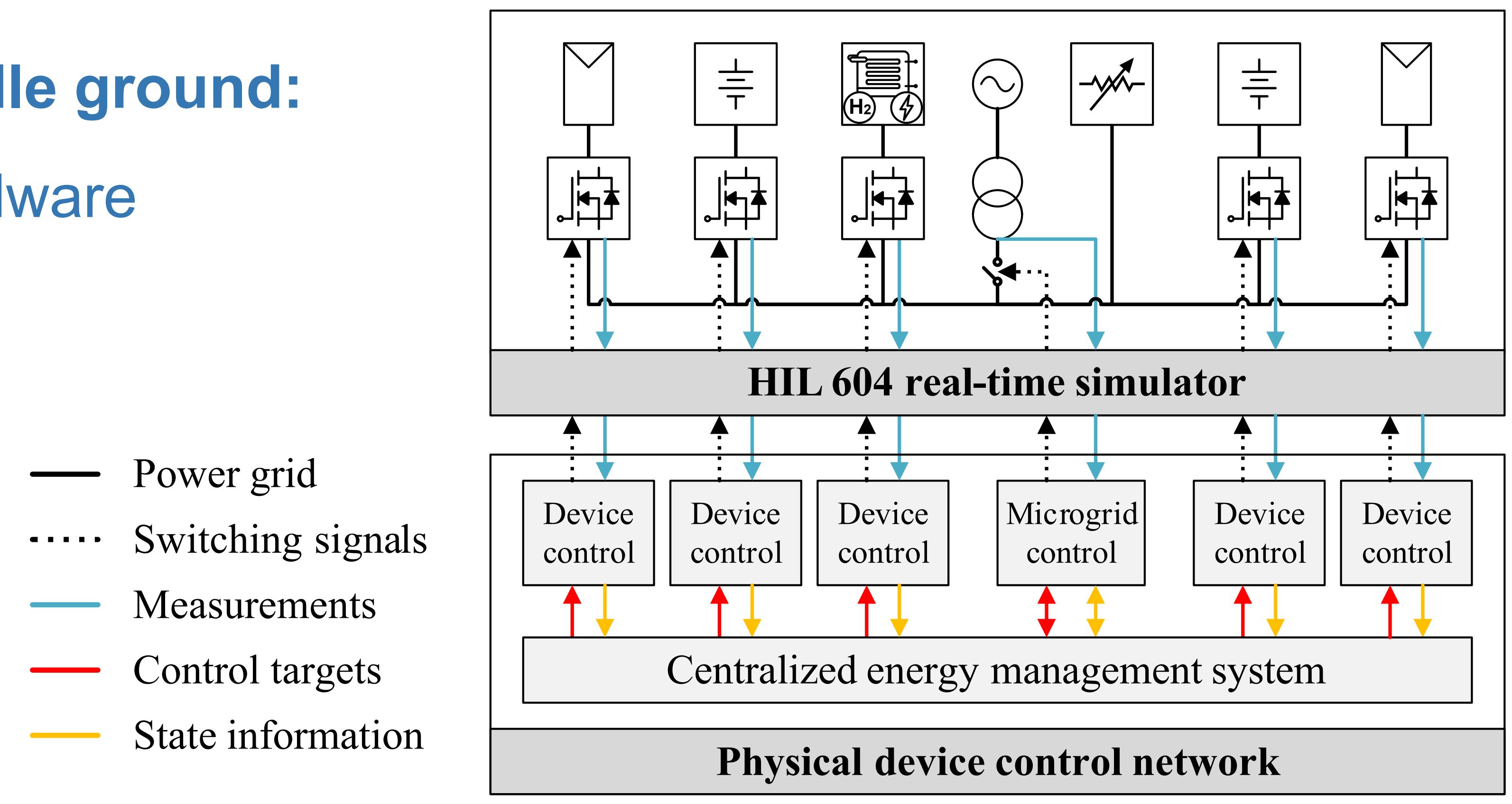
- Test 1 or 2 devices at a time
- Experimental validation
- Focus on 20 kHz to 50 Hz behaviour

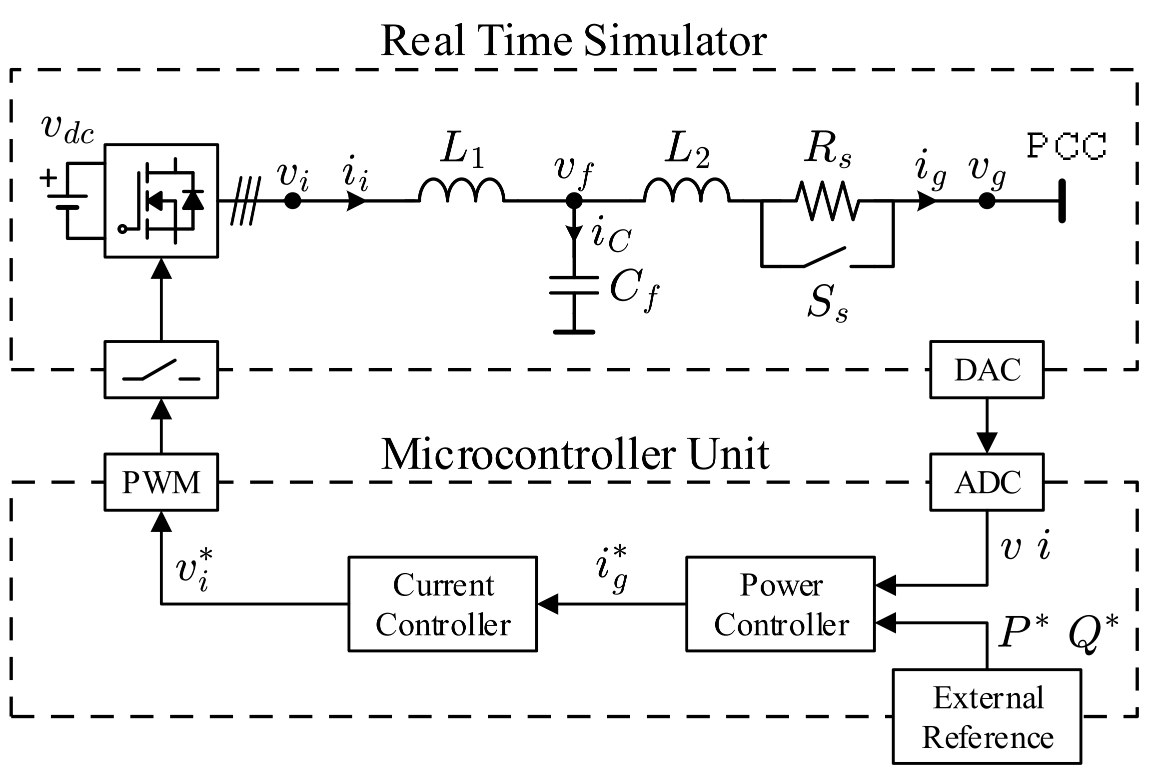
Power system dynamics:

- Test entire grids
- Simplified simulations
- Focus on 50 Hz to hourly behaviour

Controller hardware-in-the-loop as a middle ground:

- Simulated power system and inverter hardware
- Physical controllers and communication
- Test up to 6 interconnected inverters
- 1 μs temporal resolution in real time
  - ➢ 20 kHz to hourly behaviour





Build up from single inverter

- Basic building block for larger networks
- White box model enables collaboration
- Rule based design for quick reconfiguration
- Include non-ideal interfaces
  - Compensate for these when possible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