KEMA Labs

Erik de Jong

Arnhem November, 11 2022

Towards system level testing of high-power grid infrastructure

DC fast chargers

CONFIDENTIAL-LIMITED USE

CESI

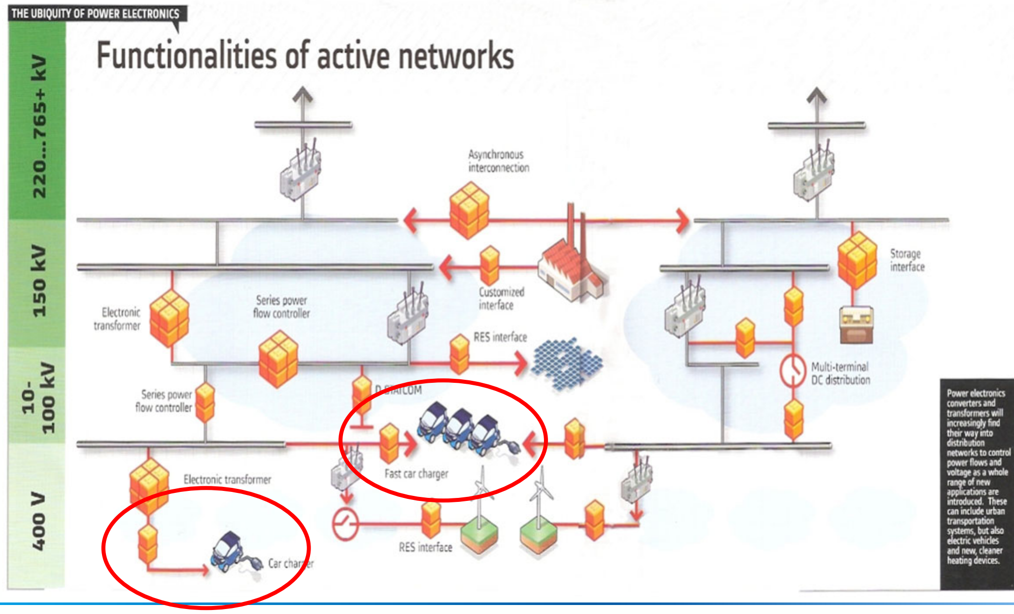
1

Content

1. *Towards system level testing*
2. *Requirements for EV infrastructure – DC chargers*
3. *Testing within TEPQEV*
4. *Final remarks*
5. *Q&A*

2

1. High-power grid infrastructure evolution



Source: IEEE

1. Testing for increased confidence

- Component testing:
  - Individual performance validation
  - Certification on component level
  - General application information
  - ='complies to standard'

↓

- System testing:
  - System performance validation
  - Validation on system level (>1 component)
  - Specific application information
  - Interaction verification
  - Dynamic behaviour
  - = 'Fit for Purpose'

2. Electrical Vehicles – DC fast chargers

5

2. *Requirements for EV infrastructure – DC chargers*

Test requirements (Lab)

- Capable of sourcing/sinking >nominal power of all EUTs simultaneously
- Allow for high short-circuit ratios to allow for realistic PQ measurements
- Adjustable test Parameters, at least:
  - **AC grid voltage**
  - **AC grid harmonic levels (individual harmonic amplitudes and angles)**
  - **DC voltage (individual for each EVSE under test)**
  - **Source impedance & LV/MV grid topologies**
  - **EVSE power setpoints (P and Q)**
  - **Independent supply for each EVSE under test**
- Suitable measurement/acquisition equipment
- Suitable emulation equipment

6

3. *Testing within TEPQEV*

All laboratory testing within TEPQEV performed:

3. KEMA Laboratories

3. KEMA Laboratories - FPGLab

The Flex Power Grid Lab (FPGLab) focuses on system level research and testing of cyber-physical systems using *Power Cybernetics* principles.

9

3. TEPQEV – Scope of system

Test requirements (HW) – DC fast chargers – Grid side

- AC power supply (e.g. 2x175kVA @ 400V,50Hz)
  - **1x3 AC voltage measurement (3P3W, High bandwidth)**
  - **2x3 AC current measurement (High bandwidth)**
- EVSE (Charging Station) – (DC, 150kWx2)
  - **AFE function (bi-directional power capability)**
  - **Local reactive power control (limited range)**

10

3. TEPQEV – Scope of system

Test requirements (HW) – DC fast chargers – Grid side

- AC power supply (e.g. 2x175kVA @ 400V,50Hz)
  - **1x3 AC voltage measurement (3P3W, High bandwidth)**
  - **2x3 AC current measurement (High bandwidth)**
- EVSE (Charging Station) – (DC, 150kWx2)
  - **AFE function (bi-directional power capability)**
  - **Local reactive power control (limited range)**

11

3. TEPQEV – Scope of system

Test requirements (HW) – DC fast chargers – Grid side

- AC power supply (e.g. 2x175kVA @ 400V,50Hz)
  - **1x3 AC voltage measurement (3P3W, High bandwidth)**
  - **2x3 AC current measurement (High bandwidth)**
- EVSE (Charging Station) – (DC, 150kWx2)
  - **AFE function (bi-directional power capability)**
  - **Local reactive power control (limited range)**

12

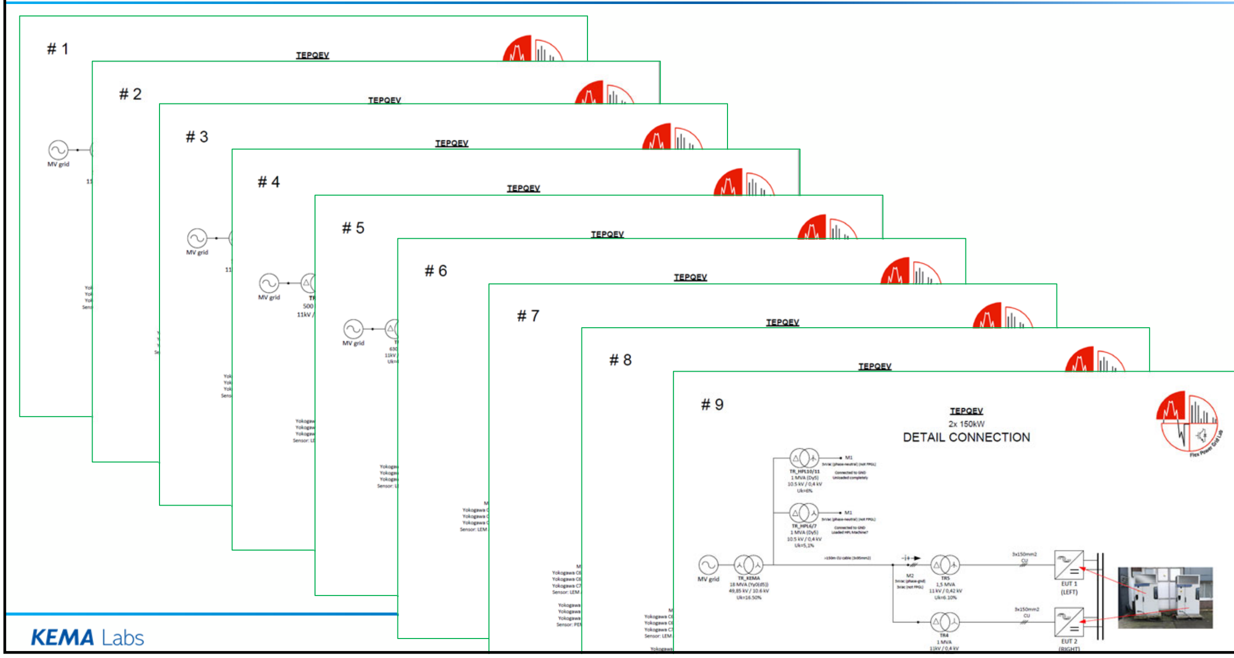
3. Testing within TEPQEV

Multiple setups engineered to facilitate investigations and testing on:

- *(supra)Harmonic emission*
- *(supra)Harmonic fingerprinting / susceptibility*
- *Interaction through grid impedance variations*

13

3. Multiple test setups realized



14

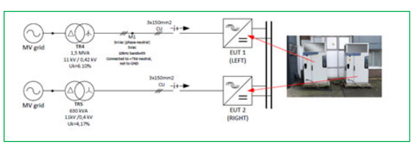
3. *Testing within TEPQEV*

Multiple setups engineered to facilitate investigations and testing on:

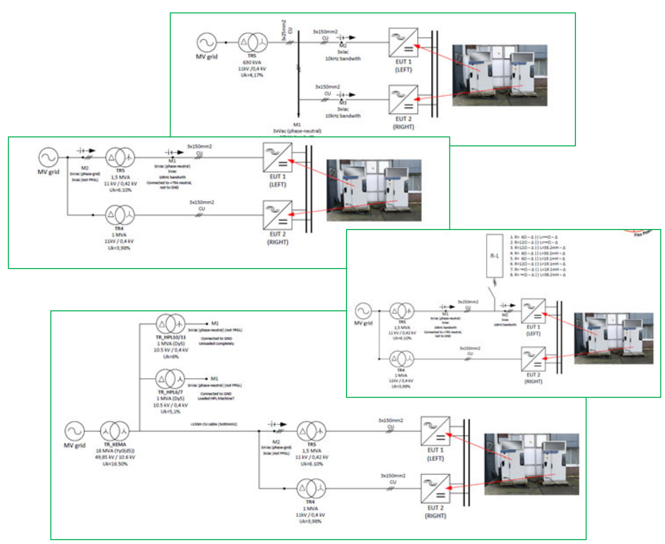
- *(supra)Harmonic emission*
- *(supra)Harmonic fingerprinting / susceptibility*
- *Interaction through grid impedance variations*

3. Multiple test setups realized

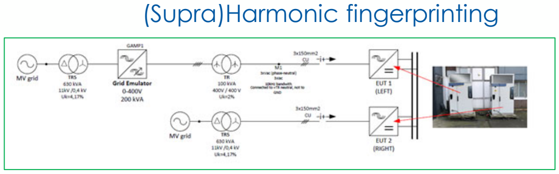
(Supra)Harmonic emission



Interaction and supply impedance variations



(Supra)Harmonic fingerprinting



3. *Testing within TEPQEV*

Multiple setups to facilitate investigations and testing

- *(supra)Harmonic emission*
- *(supra)Harmonic fingerprinting / susceptibility*
- *Interaction through grid impedance variations*

Emulators key to efficient and repeatable testing, independent of EV specific characteristics.

- *AC grid simulator*
- *DC-enabled EV simulator*
- *(bespoke) back-to-back configuration*

3. Emulators used - AC

AC Power supply configurations capable of four-quadrant operation, include:

High-power (1 MVA), High-voltage:

- **three-phase-four-wire (3p4w) up to 24 kV (3 phases independently controllable), control bandwidth up to 1800 Hz;**
- **single-phase-two-wire (1p2w) up to 50kV, control bandwidth up to 1800Hz;**

High-power (200kVA), Low-voltage:

- **multiple (at least 4) 3p4w configurations supported up to 440 V; control bandwidth up to 10kHz; can be driven by a real-time simulator (SFP link);**

3. Emulators used – EV (DC-CCS2)

EV simulator:

- CCS1/CCS2 (up to 350kW) :
  - 0-1500Vdc
  - ISO15118-4 (V2G)
  - ISO15118-5 (SLAC)
  - DIN70122
- CHADEMO:
  - Not used in TEPQEV;
- GBT (China):
  - Not used in TEPQEV;

4. Final remarks

This presentation gave an overview of:

- *Testing of high-power grid components from a laboratory testing point of view*
- *The future direction of (system-level) testing and why the evolution is necessary*
- *The numerous TEPQEV lab test setups used that lead to the results presented by Tim Slangen, earlier today*

KEMA Labs

Milan · Arnhem · Berlin · Mannheim · Prague · Chalfont · Dubai · Dammam · Santiago de Chile · Rio De Janeiro · Knoxville (USA) · Shanghai

CONFIDENTIAL-LIMITED USE

CESI

21