EnerHarv 2024

PSMA International Workshop | 26-28 June, 2024 | Perugia, Italy

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EnerHarv 2024 Workshop:

Energy Harvesting and Power Management for a retrofittable Current Sensor for Grid Condition Analysis

Presented By –

Gerd vom Bögel, Dr.-Ing.

Fraunhofer IMS

gerd.vom.Boegel@ims.Fraunhofer.de

Fraunhofer IMS

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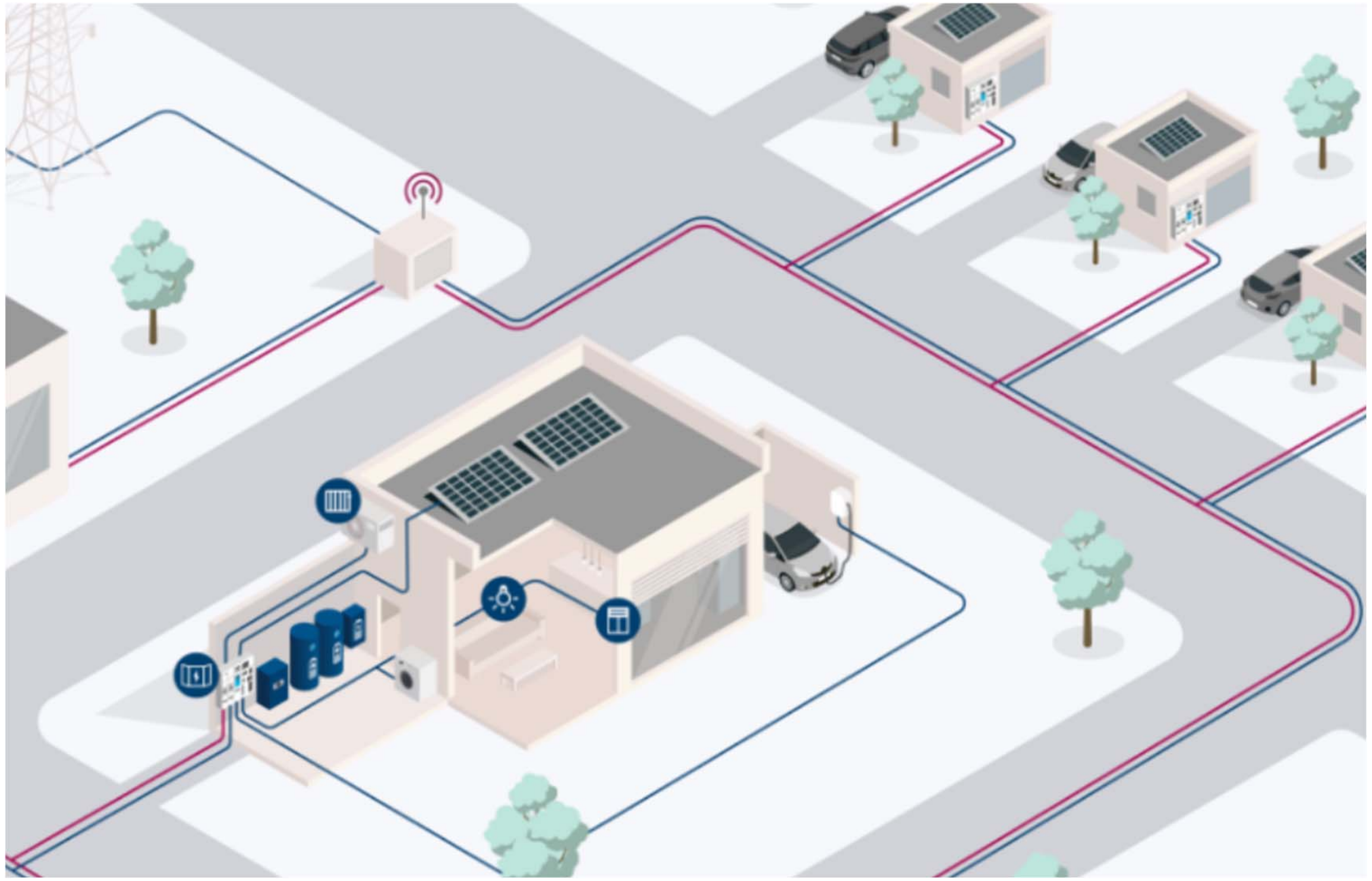
OVERVIEW

- **Motivation**
- **Challenges**
- **Concept**
- **Harvester and Power Management**
- **System Integration**
- **Conclusion**



Motivation

In general

- Making the distribution grid transparent
- Detection of overloads
- Detection of faults (fuses, switches etc.)

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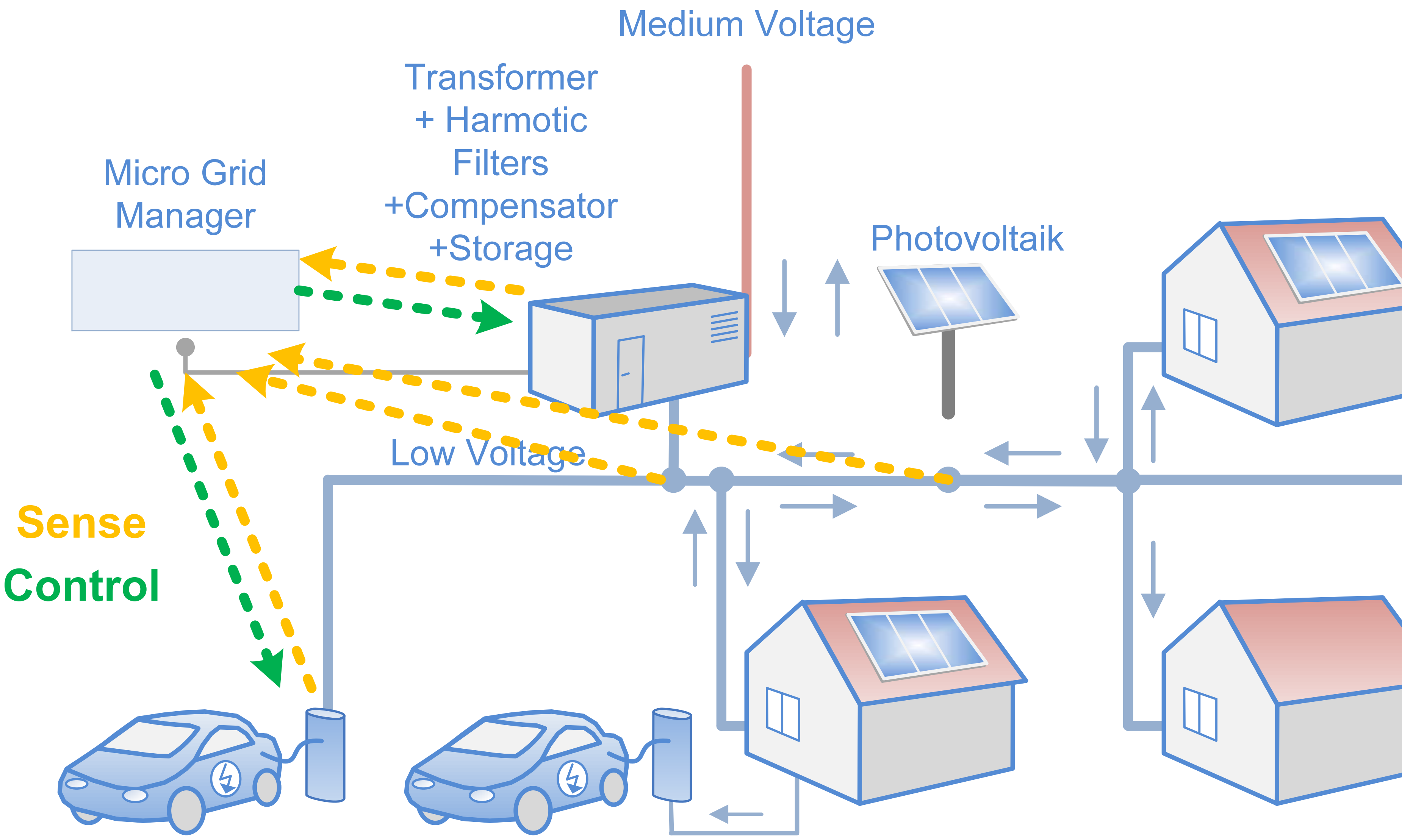
- Providing a sensor system, that
    - Is low cost in installation
    - Is low product price
    - Is not a high accuracy sensor (not for accounting)

Requirements

- Security
- Reliable RF communication
- High availability



Key Parameters of the Smart Grid Sensors

Current range in primary conductor for energy harvesting	**Min 5 A rms, Max 300 A rms**
Measured physical values	Current, Voltage (low accuracy) Phase Current, Phase Voltage, Temperature, Humidity
Measured parameters and extracted features	Current RMS, Current/voltage phase, Peak current Active and reactive power Temperature absolute and gradient Total harmonic component
Local signal analysis	Alarm on limit violation of feature values (event detection)
Connectivity	LoRaWAN or NB-IoT
Data transmission interval	Every 15 min transmission of features Immediately in case of event (alarm)

Challenges

Harvester

- Operating Range 5 A to 300 A primary current -> 1:3600 power input ratio
- Overvoltage protection -> 3 kV test pulses from grid operator for shortcut detection

RF

- Duty cycle 1% -> 14 mins airtime/day ≈ 4 x 20 byte msg/h (at LoRaWAN- SF9)

Alarm

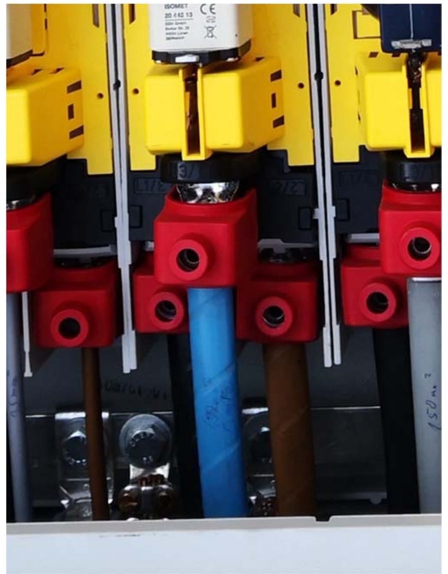
- Real time requirements -> 100 ms (from sensor to backend)

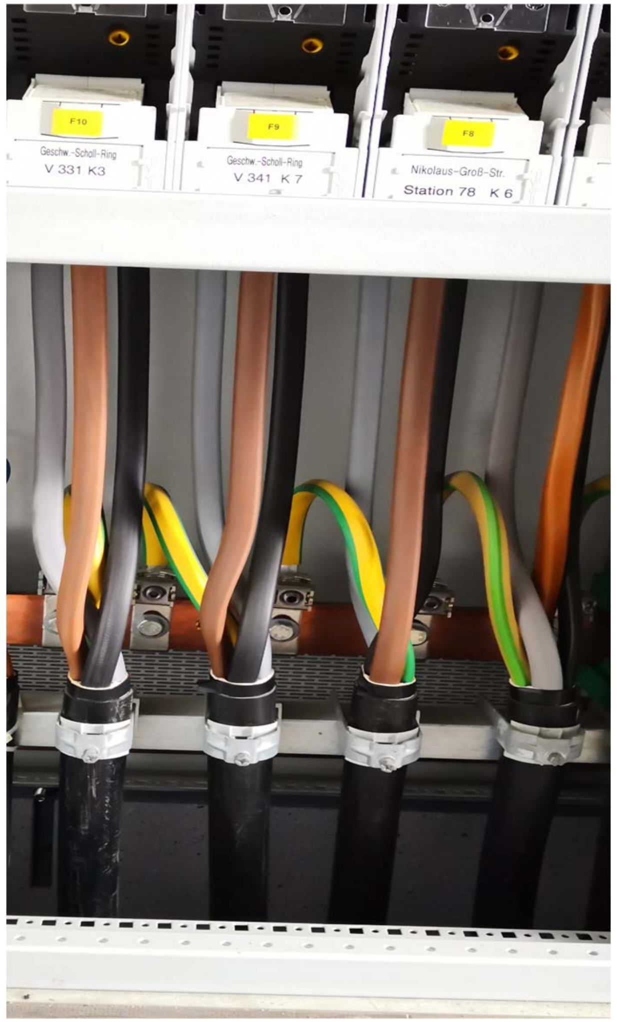
Cost

- Product and installation costs

Concept: Mounting Points of Sensors

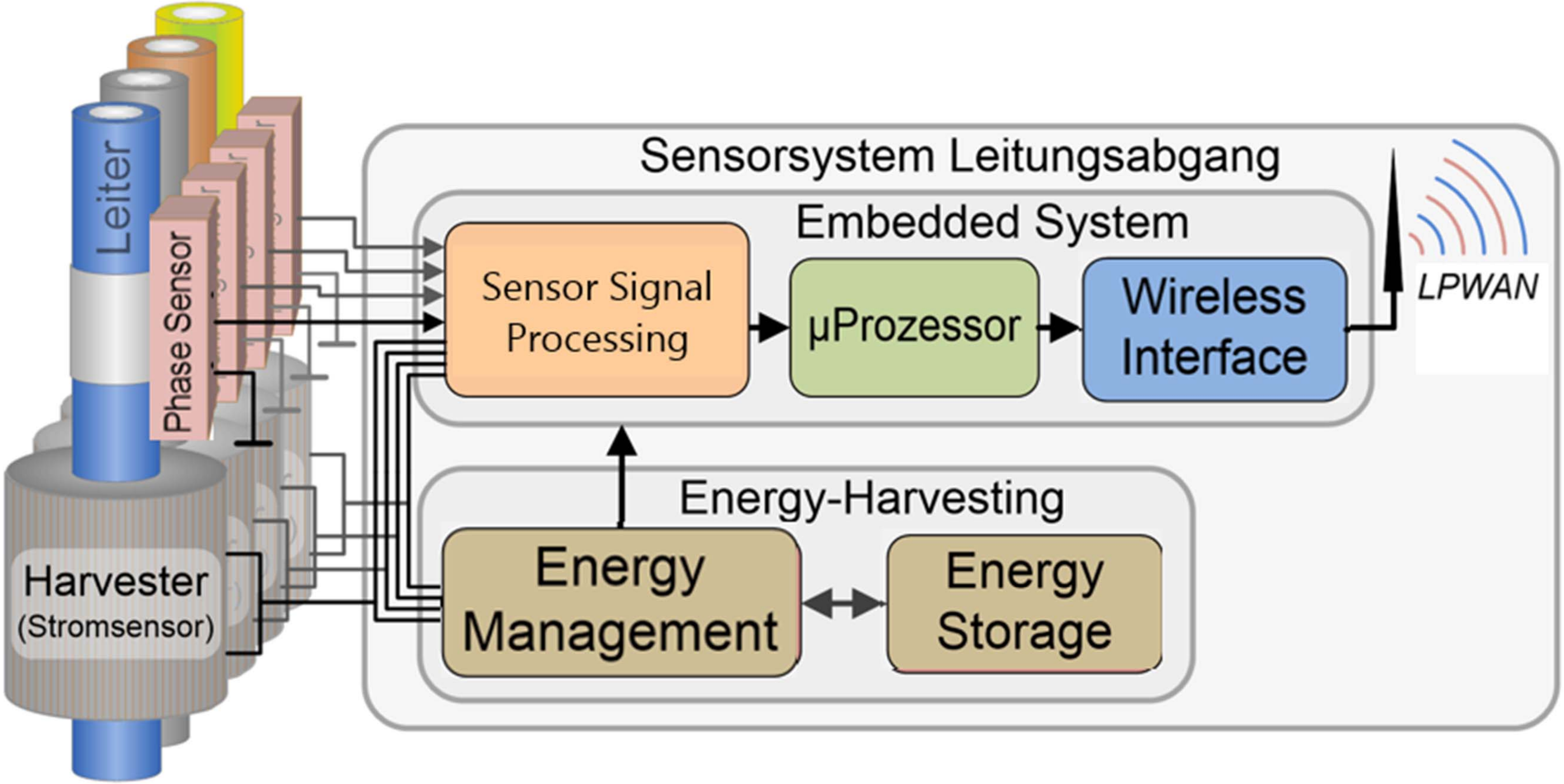
Electrical cabinets





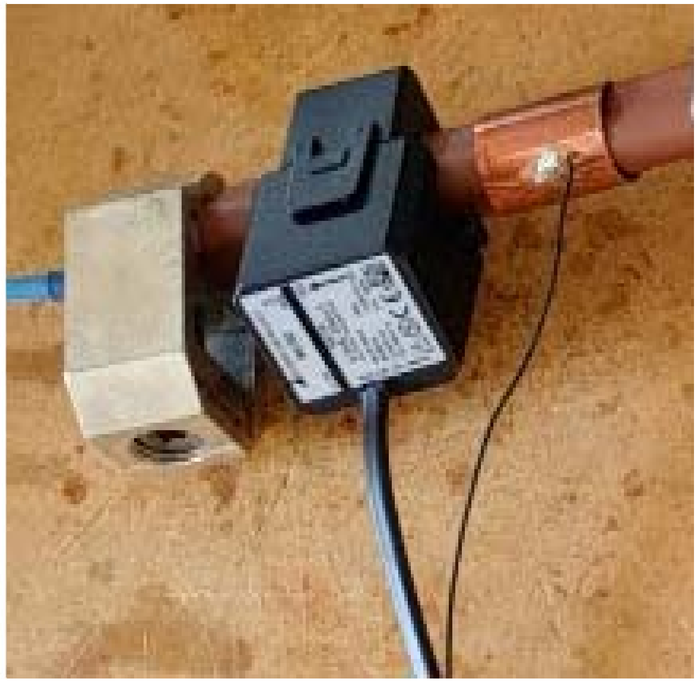
Transformer stations

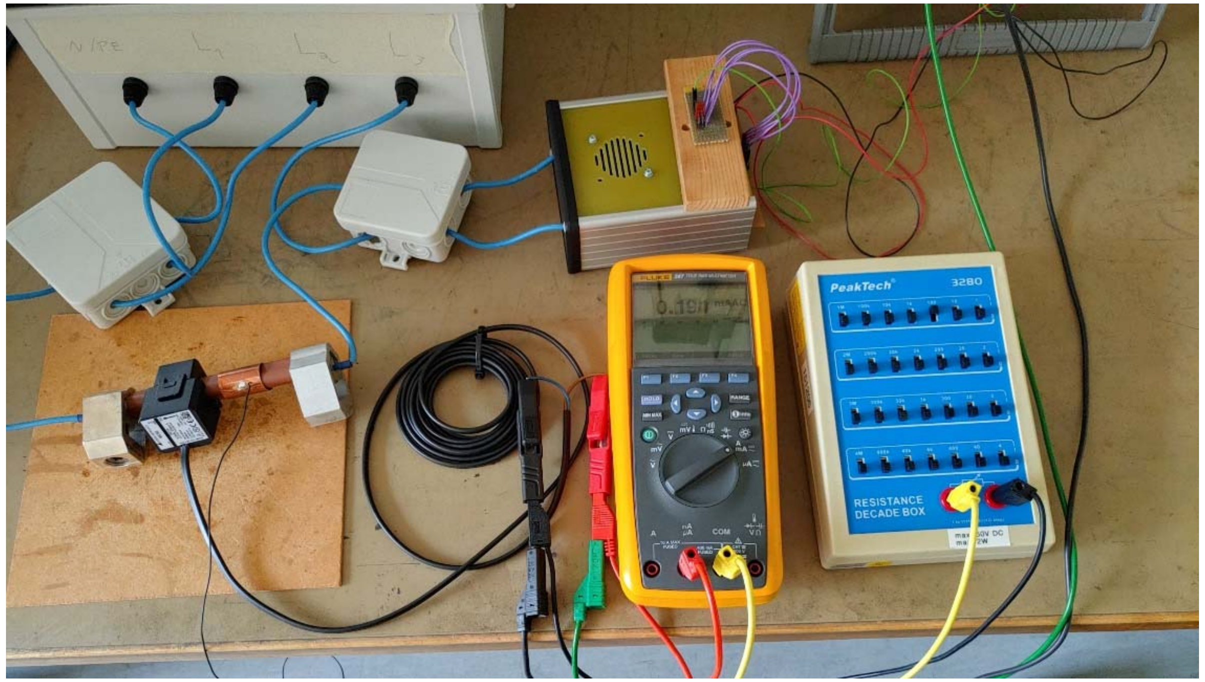
Concept of the Sensor Module



Frontend – Harvester Test Setup

- Laboratory setup for measuring power transfer with commercially available current transformers





Power Demand Estimation

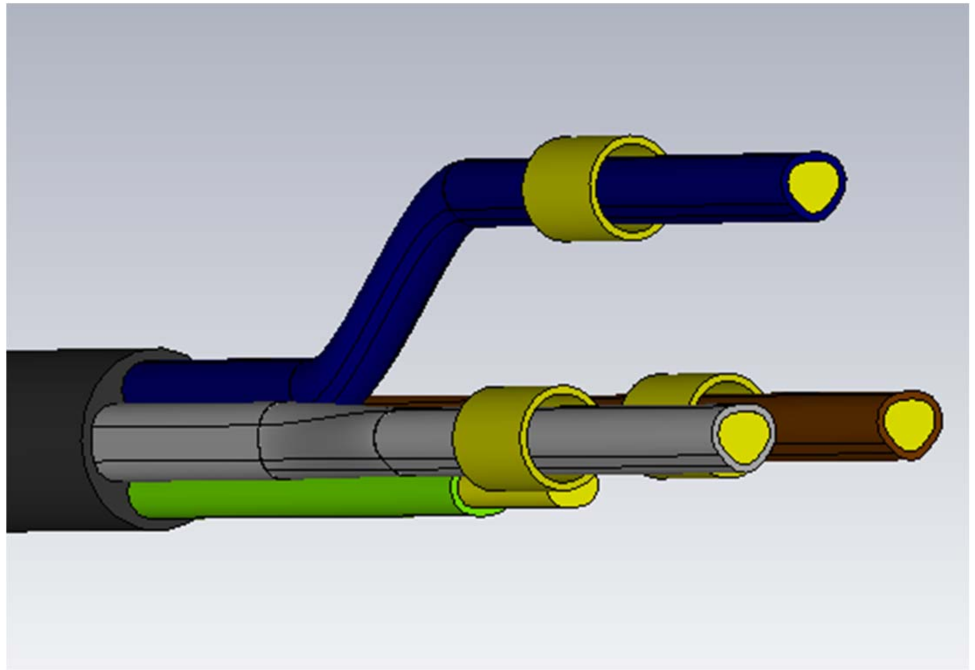
- Supply Voltage 3.3 V
- Two modes of operation:
  - full featured mode
    - Event detection
    - High sampling rate
    - Synchronized transmission
  - minimum featured mode
    - Threshold detection
    - Periodical transmission
- Result
  Functioning already at low currents

Mode	Full Featured Operation		Minimum Featured Operation	
Part/Function	Current [mA]	power [mW]	Current [mA]	power [mW]
Microcontroller:	30	99	5	16
RF-Frontend	10	33	1	3
Analog filters:	10	33	1	3
ADC:	30	99	5	16
Regulator:	10	33	5	16
Sum	**90**	**297**	**17**	**54**

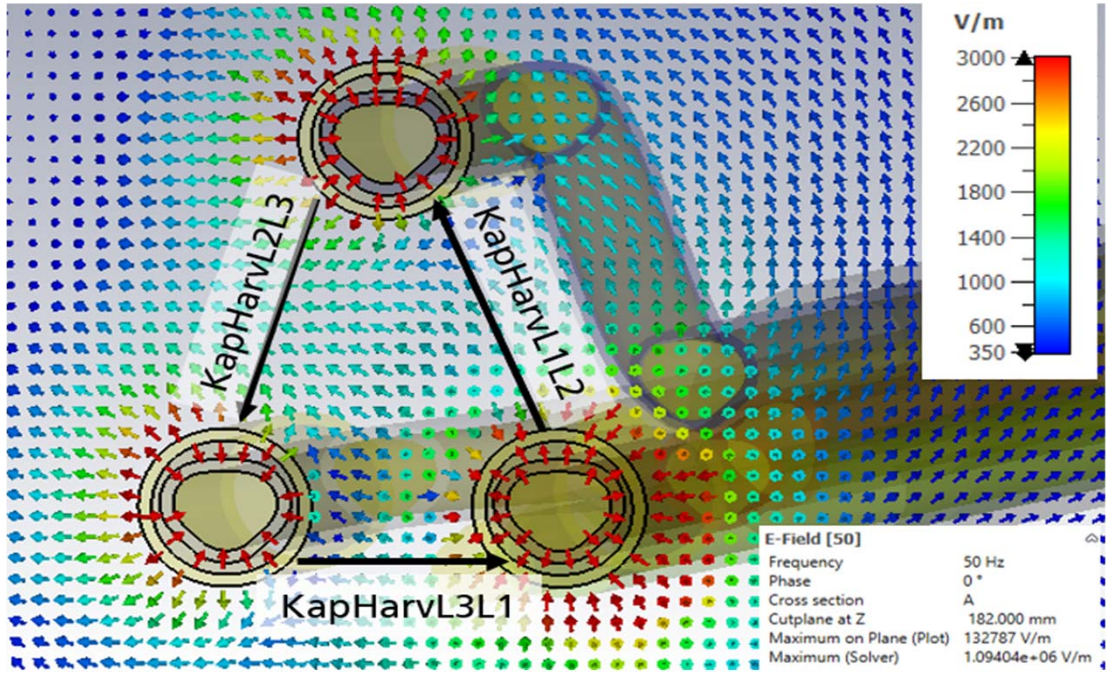
Frontend – Determination of the Phase

- Capacitive Coupling of the voltage by use of metallic sleeves around the conductors
- Simulation model of the capacitive measurement system
  for the detection of the voltage phase (zero crossing of the voltage)

Left: Simulation model



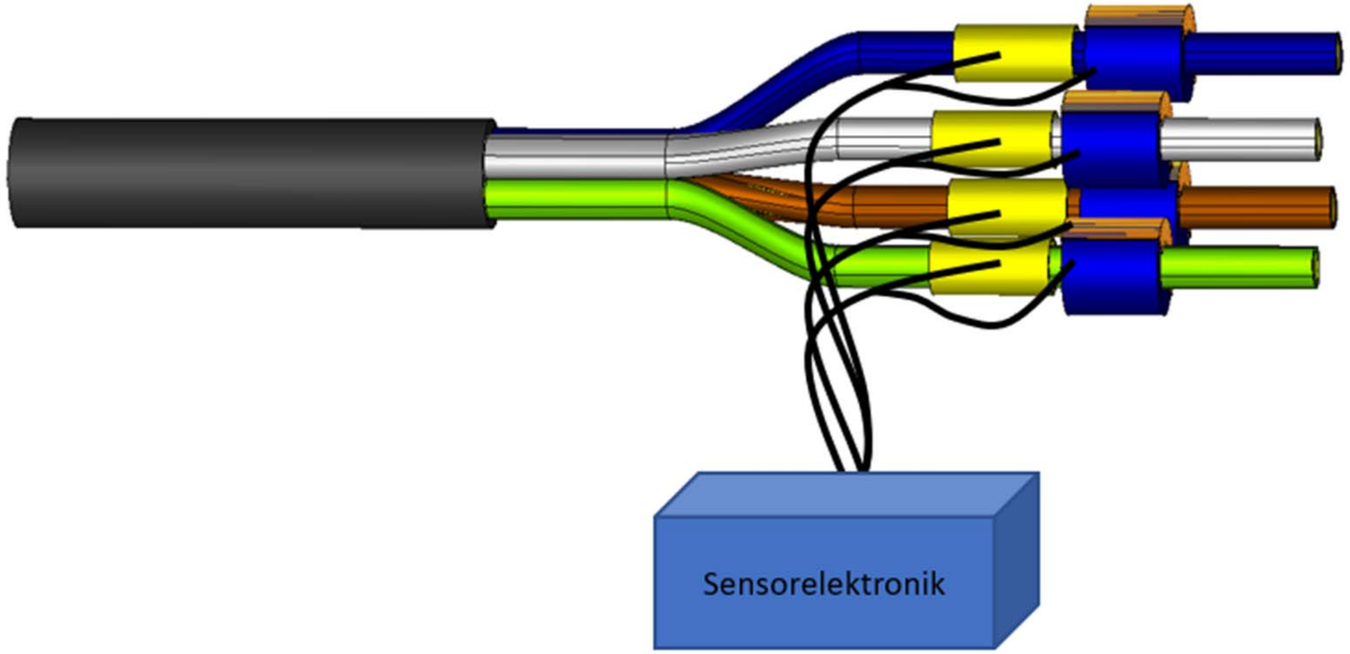
Right: Electric field lines between the sleeves

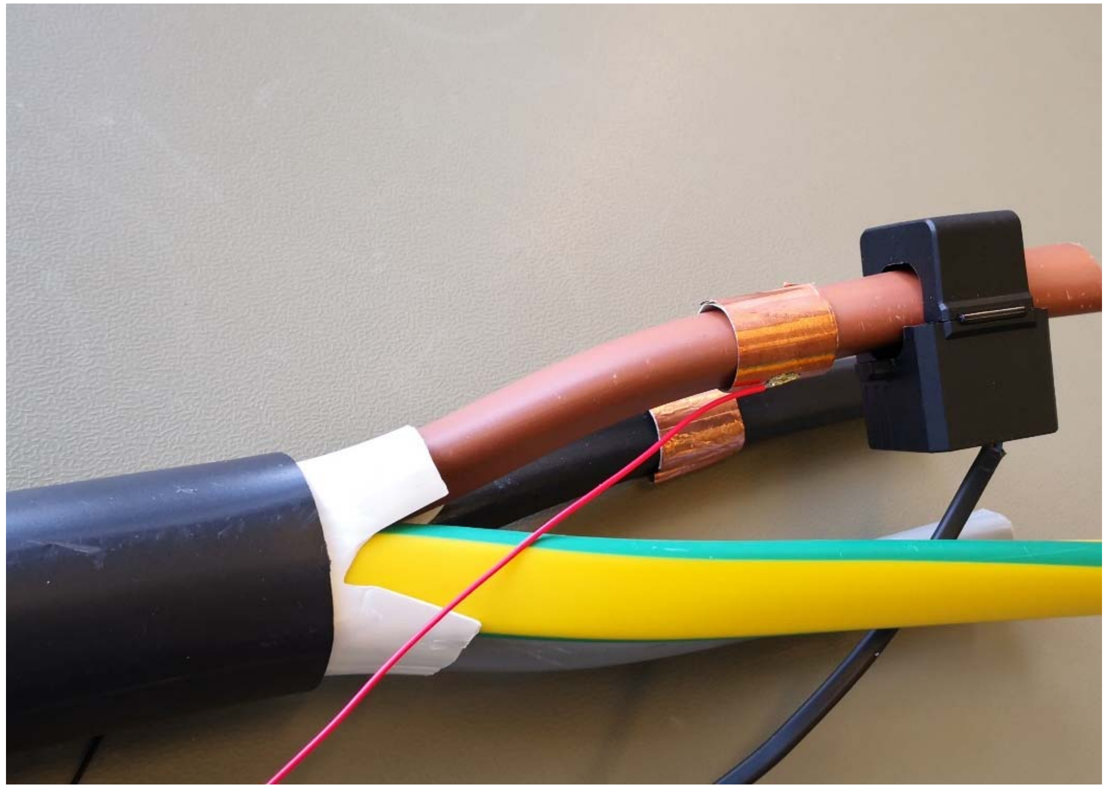


Mounting of the Sensors

Achievements:

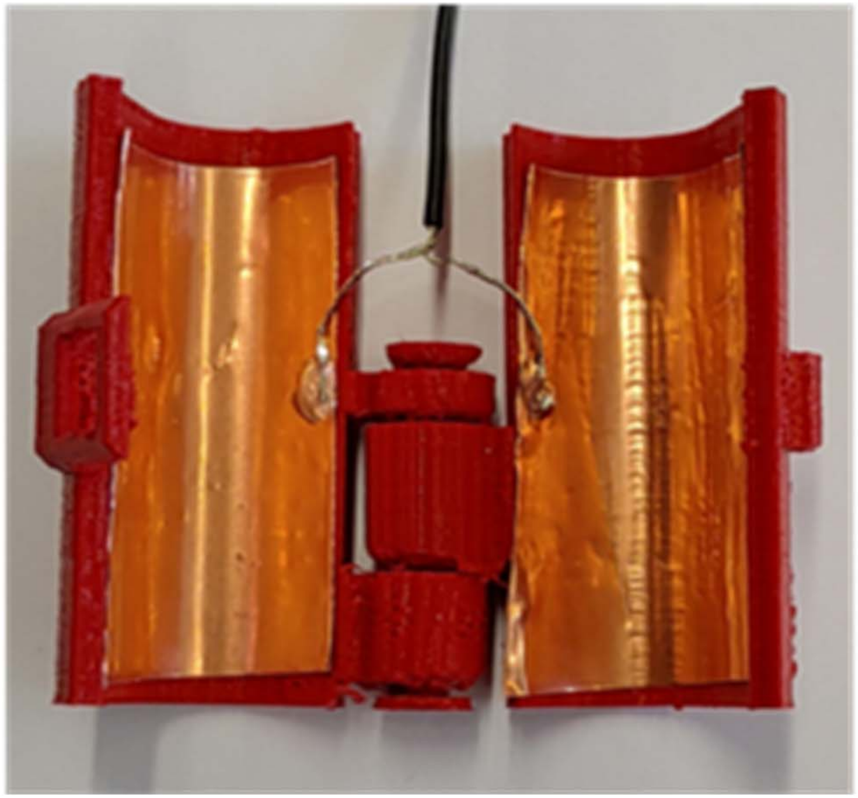
- o Concept of retrofittable current sensors ready,
- o Concept for additional Voltage measurement included
- o Dimensions
  - o Harvester 50 x 40 x 30 (4 pcs.);
  - o Electronics: 120 x 100 x 40 mm

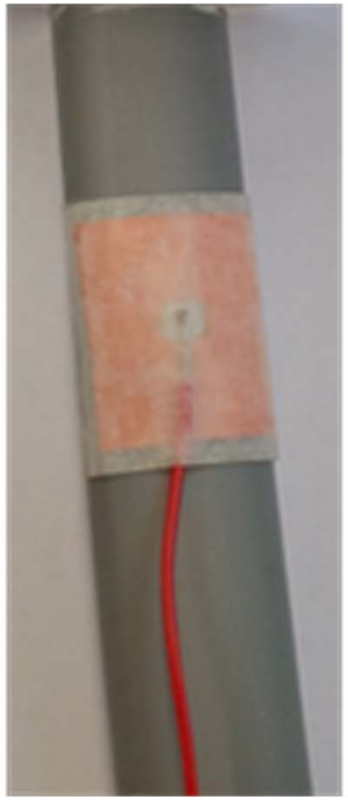
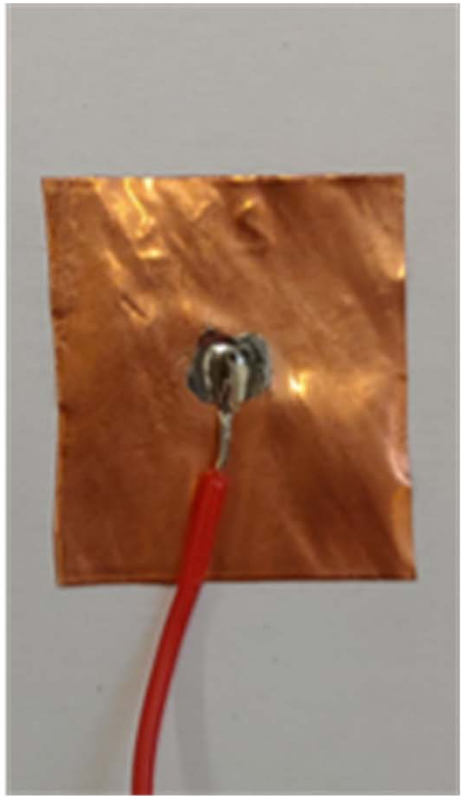




Mounting of the Sensors

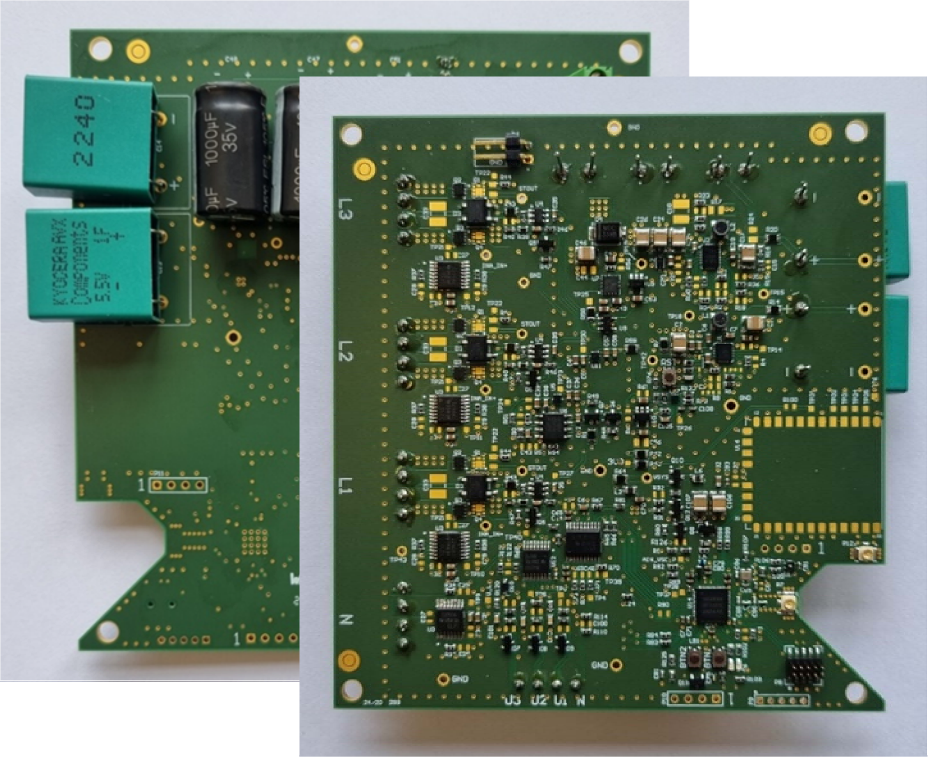
Patches for capacitive coupling



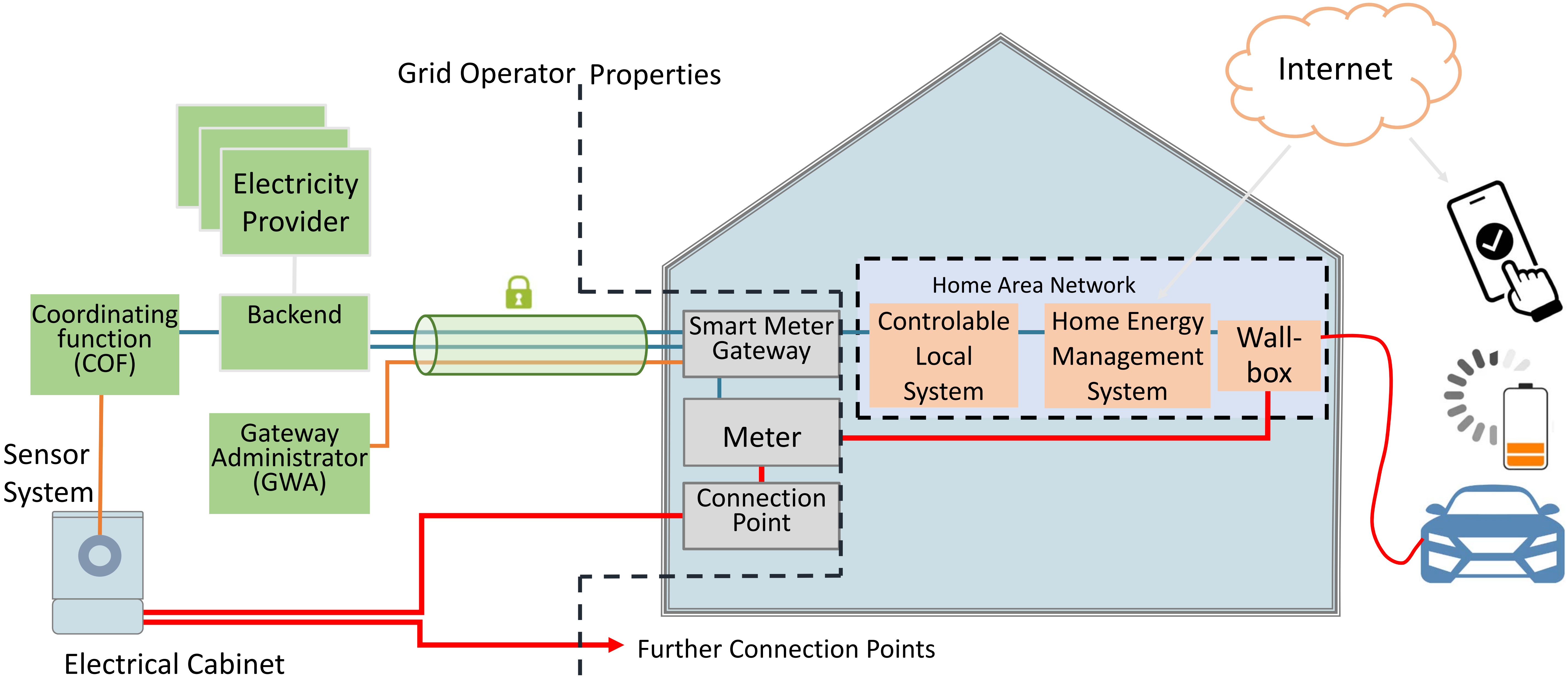



Electronics and Test Setup

- PCB (front and back side)
- Housing
- Demo and test setup

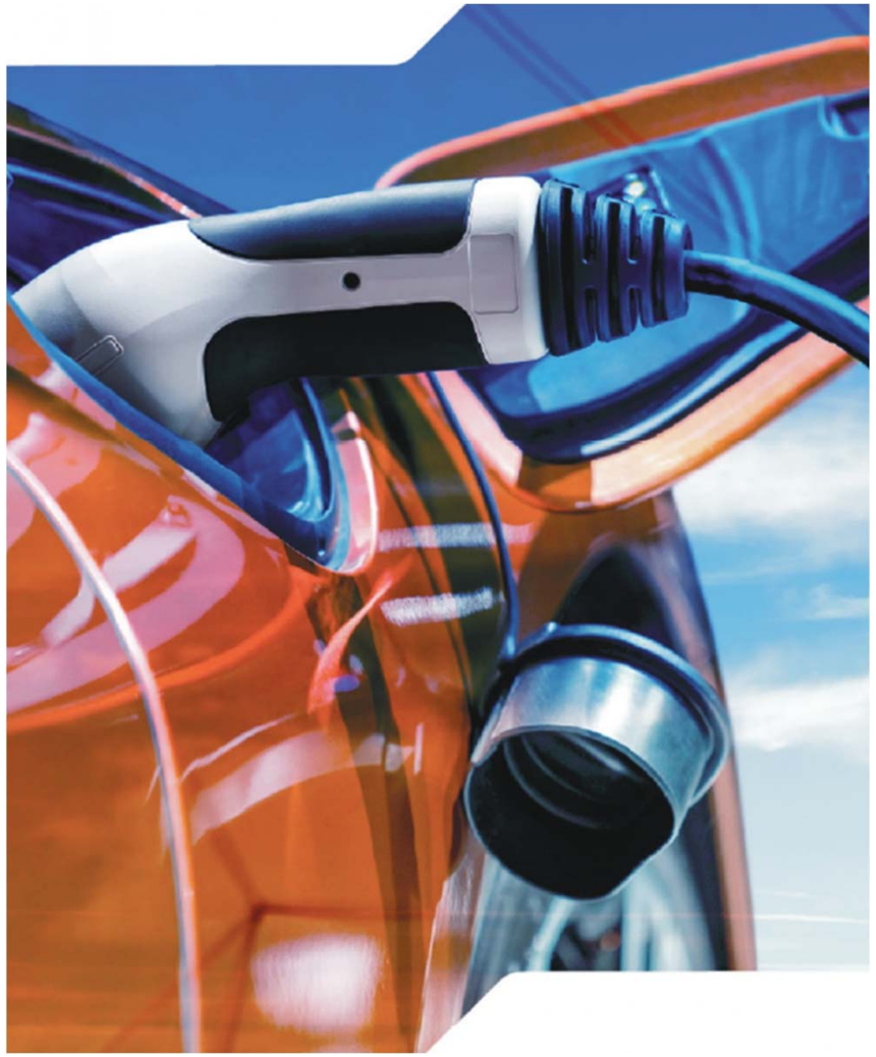


System Integration



Conclusions

- Focus of this work is the digitization of the distribution grid, with:
  - Giving transparency of the load at nodes
  - Status information
  - Enabling the control of the grid
- Self-sufficient wireless sensors
  - Easy to install
  - Cost efficient
- Pilot testing starting in 05/2024
  - 3 Pilots at different locations
  - Integration in existing grids
  - Switching of loads in demo-sites



Q & A

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Thanks very much for your time and attention!

Questions/comments???

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