PDiM : Inverter Testbed Workshop Chalmers University

29/11/2018

Agenda

- What is a drivetrain inverter?
- Why testing the inverter?
- Requirements to test the inverter?
- The AVL inverter testbed

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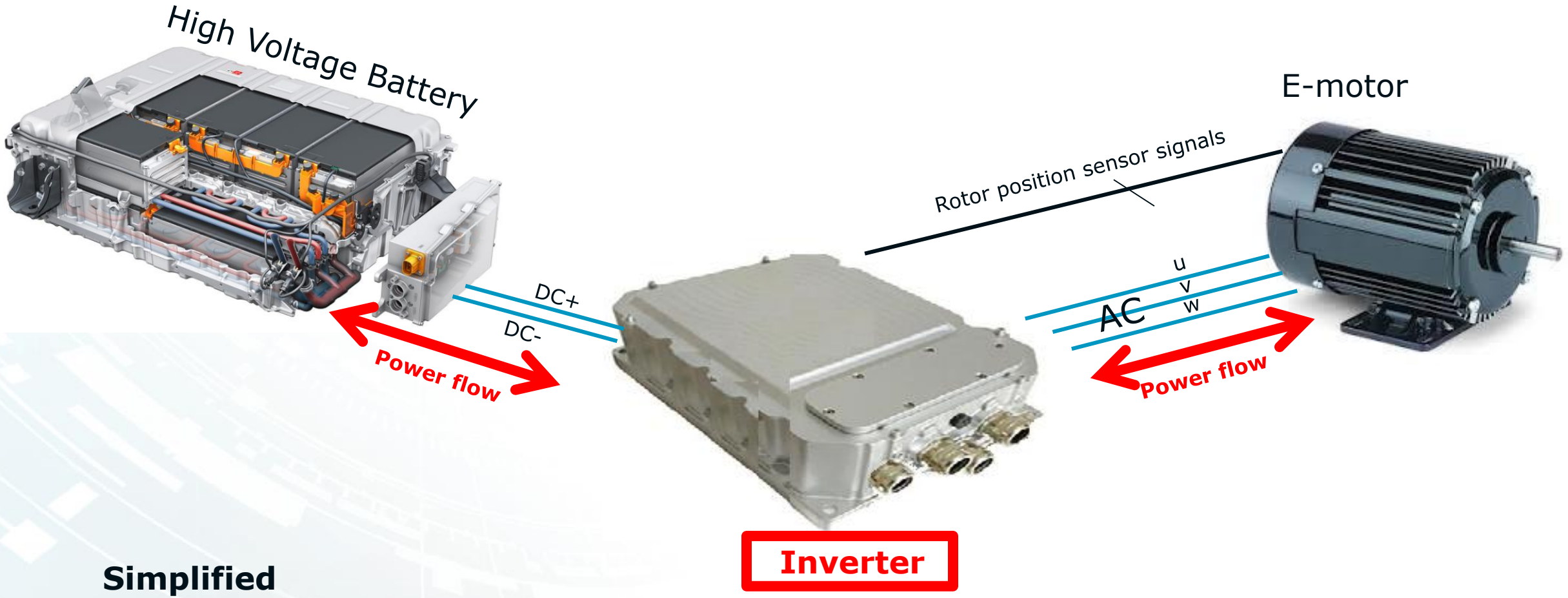
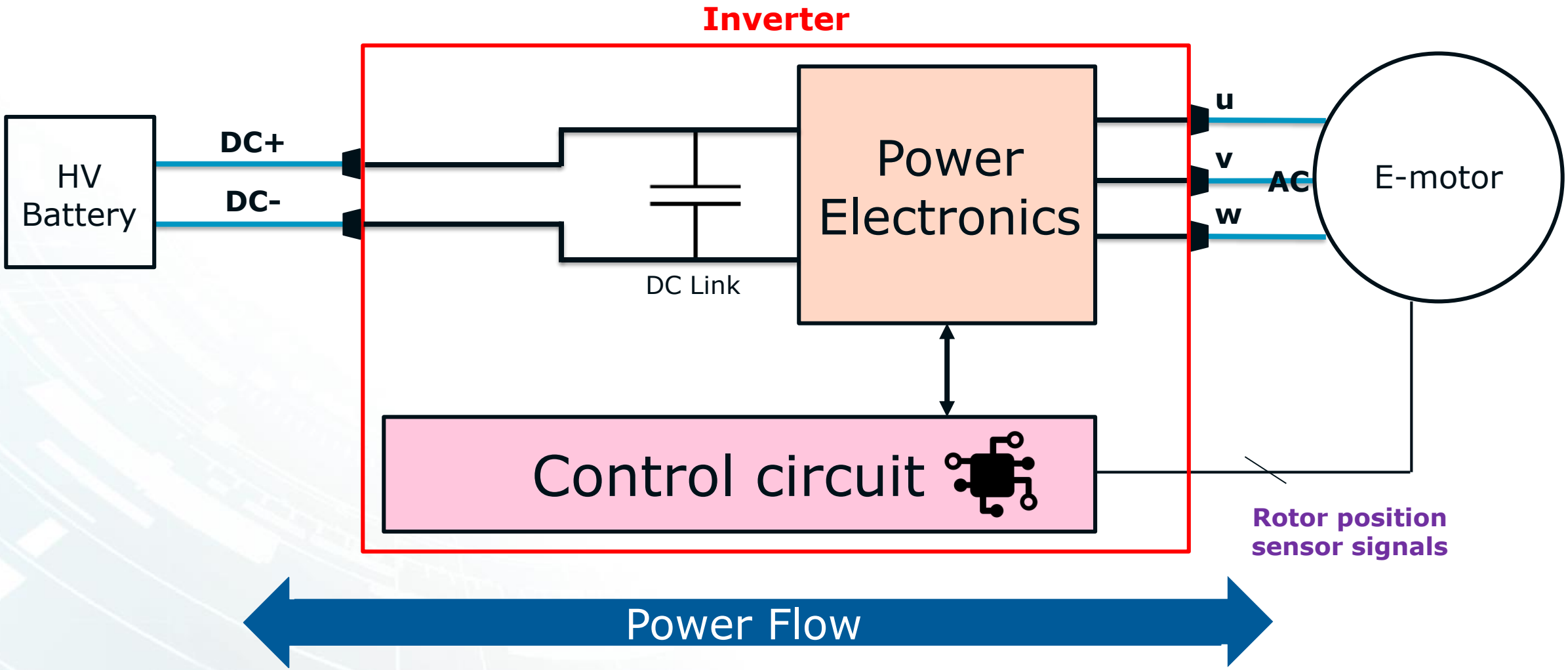
What is a Drivetrain Inverter?



Simplified Electrical Powertrain

What is a Drivetrain Inverter?



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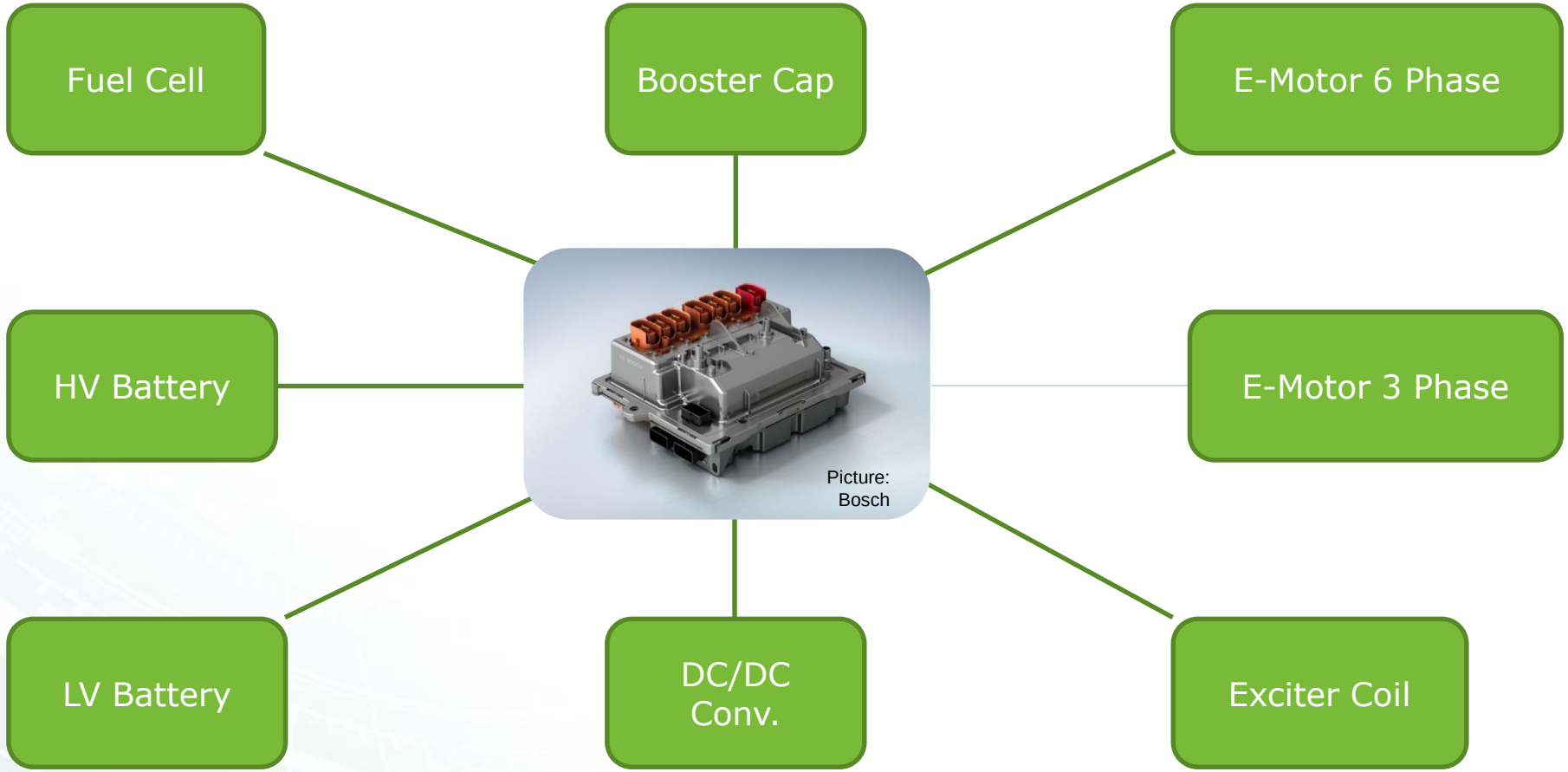

The inverter can have multiple power interfaces

What is a Drivetrain Inverter?

Customer statement:

"We plan to develop our own inverter mainly for two reasons :

1. *The inverter has become a key component regarding **safety**, **performance** and **drivability** with big possibilities for optimizations and improvements.*

2. *80% of the potential margin of the e-Drive (eMotor + inverter) is today in the inverter, not the eMotor."*

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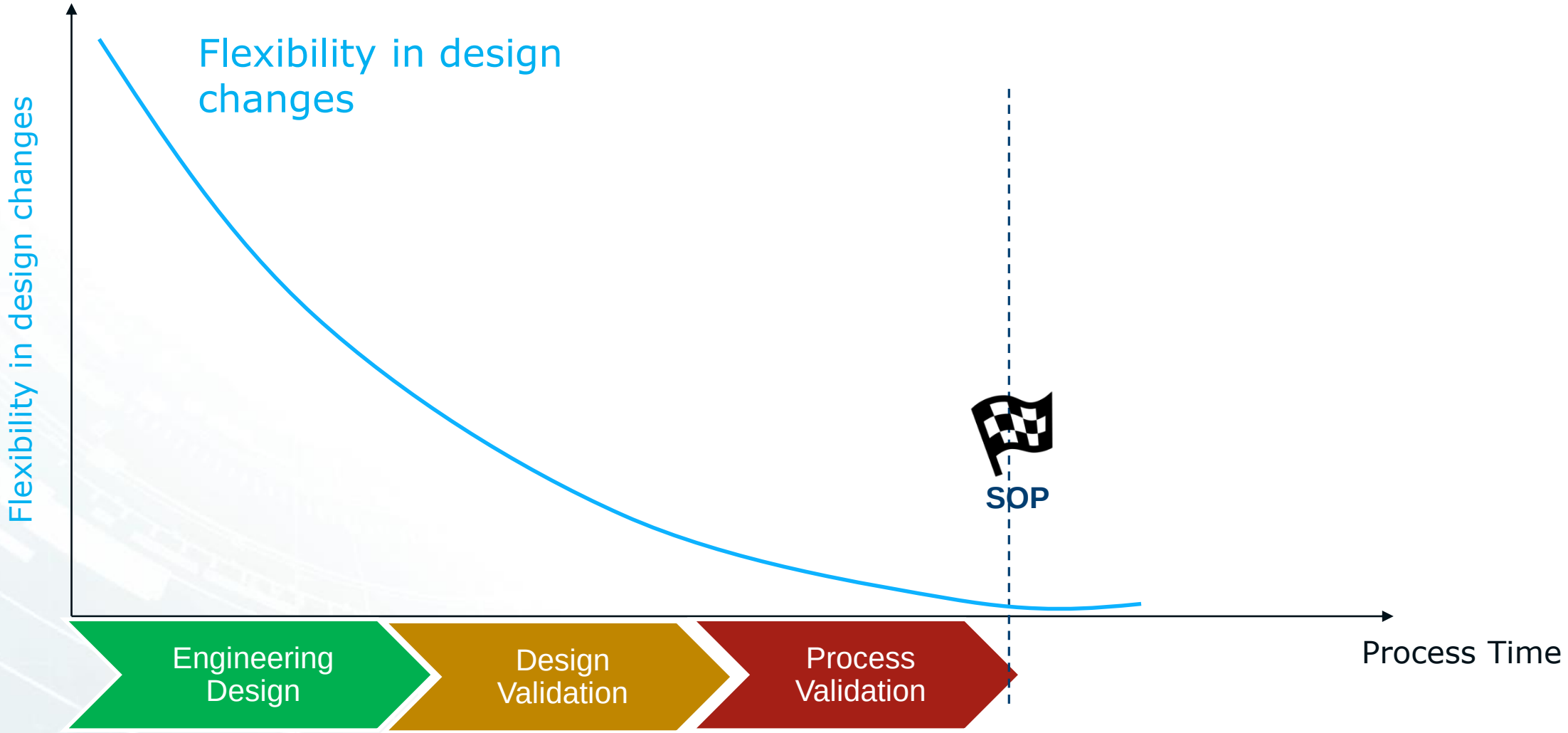
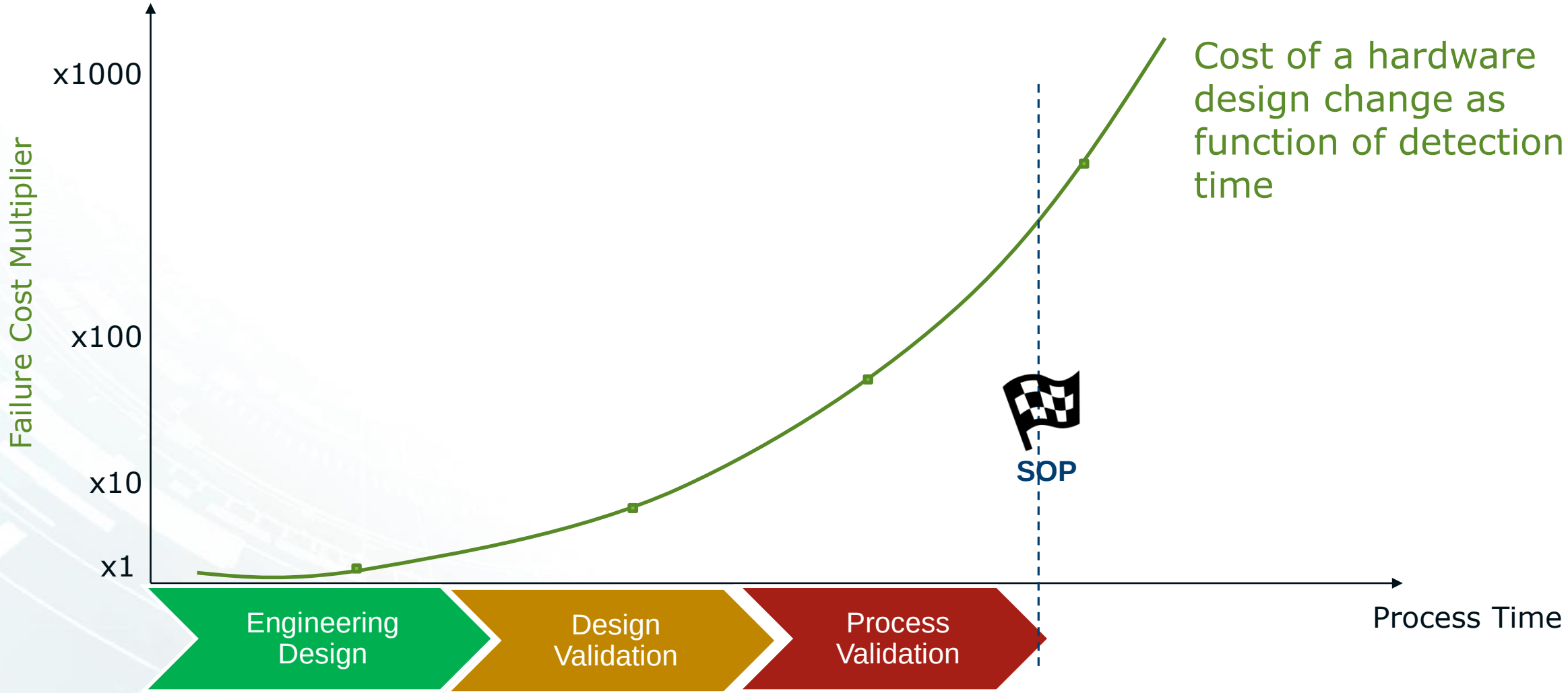
Why testing the inverter?

A major failure was detected on the field, with several units already sold to the customers

Why testing the inverter?



Why testing the inverter?



Cost of a hardware design change as function of detection time

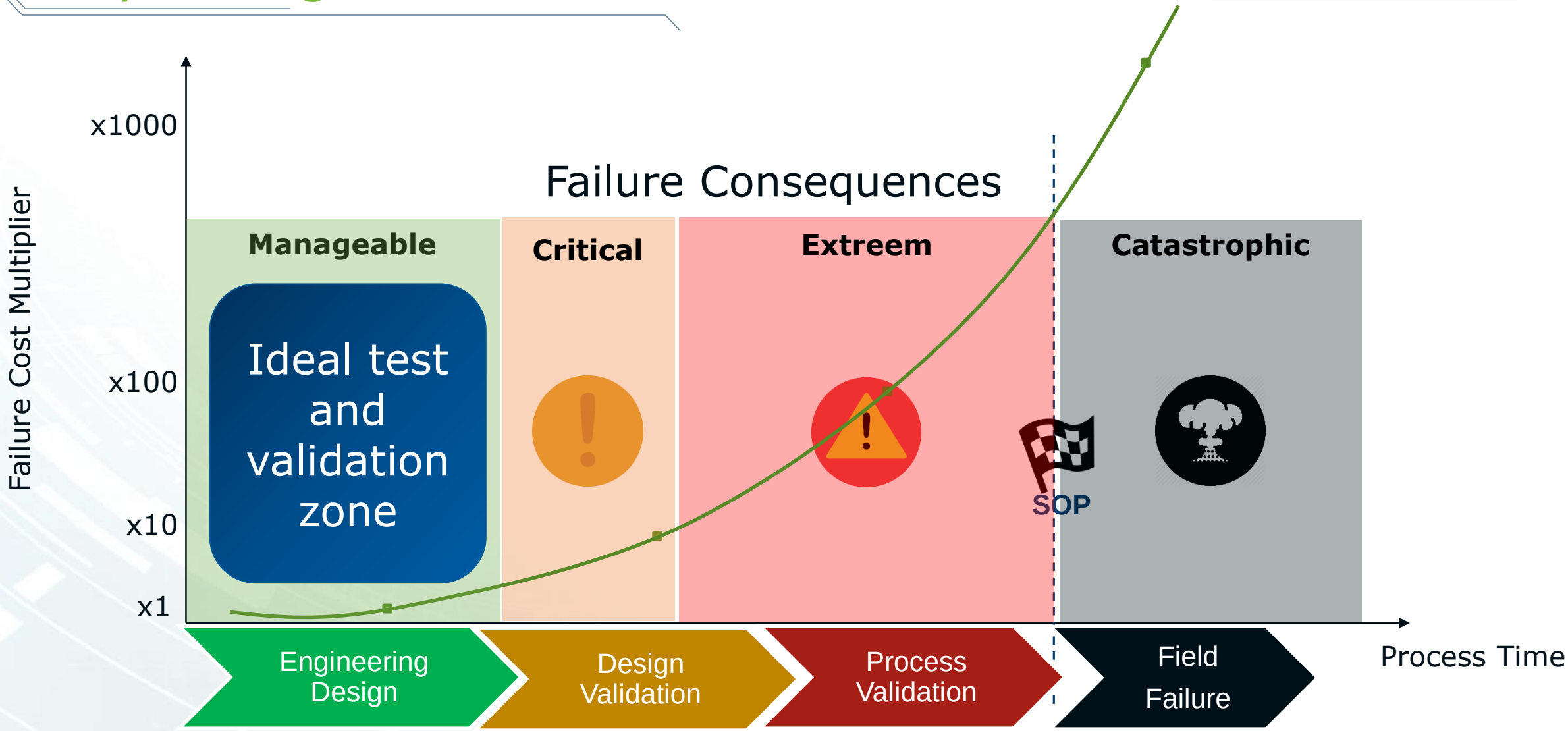
Why testing the inverter?

Customer statement:

"If a failure requiring a change in the inverter hardware design exists,
each additional month passing without detecting it
multiplies by 10
the overall cost of the modification.

Having the possibility to detect a failure
6 months earlier in our development process
potentially saves 1M€…"

Why testing the inverter?



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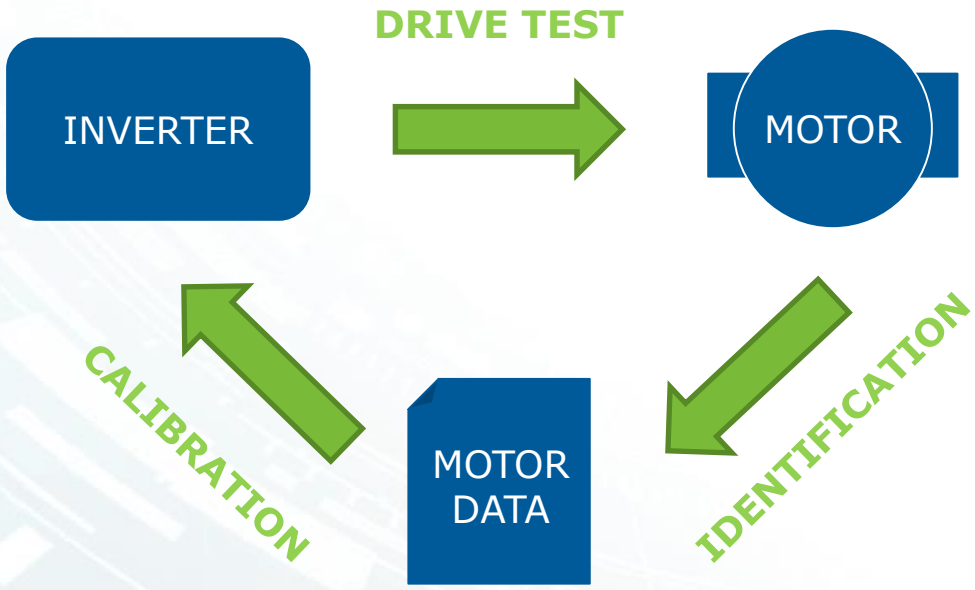
Requirements to test the inverter?

First level of complexity:



Typical test setup

Few common issues:

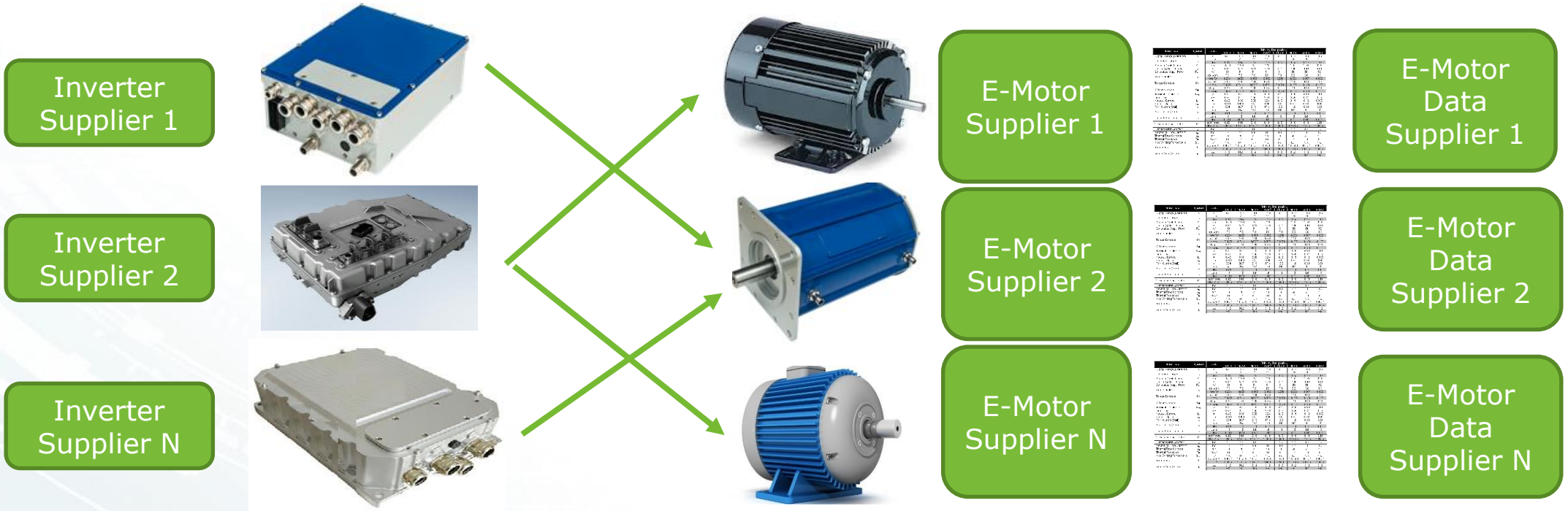
1. Is the eMotor available?
2. Is the eMotor validated?
3. Do the motor data fit 100% the eMotor?
4. What is the influence of the motor temperature during the tests?

Root cause:

The UUT is not isolated

Requirements to test the inverter?

Second level of complexity:



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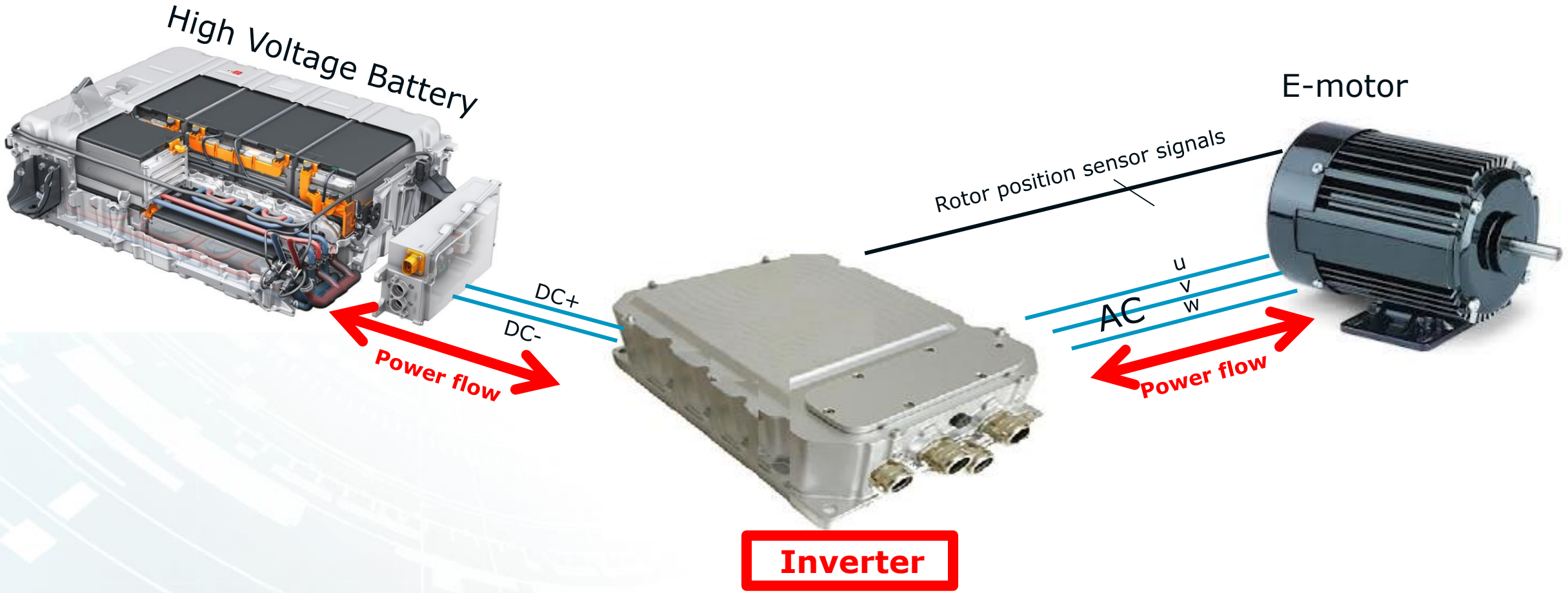
AVL Inverter Testbed : Power HiL based



AVL Inverter Testbed : Power HiL based

Battery Emulator

DC+

DC-

Power flow

Inverter

Rotor position sensor signals

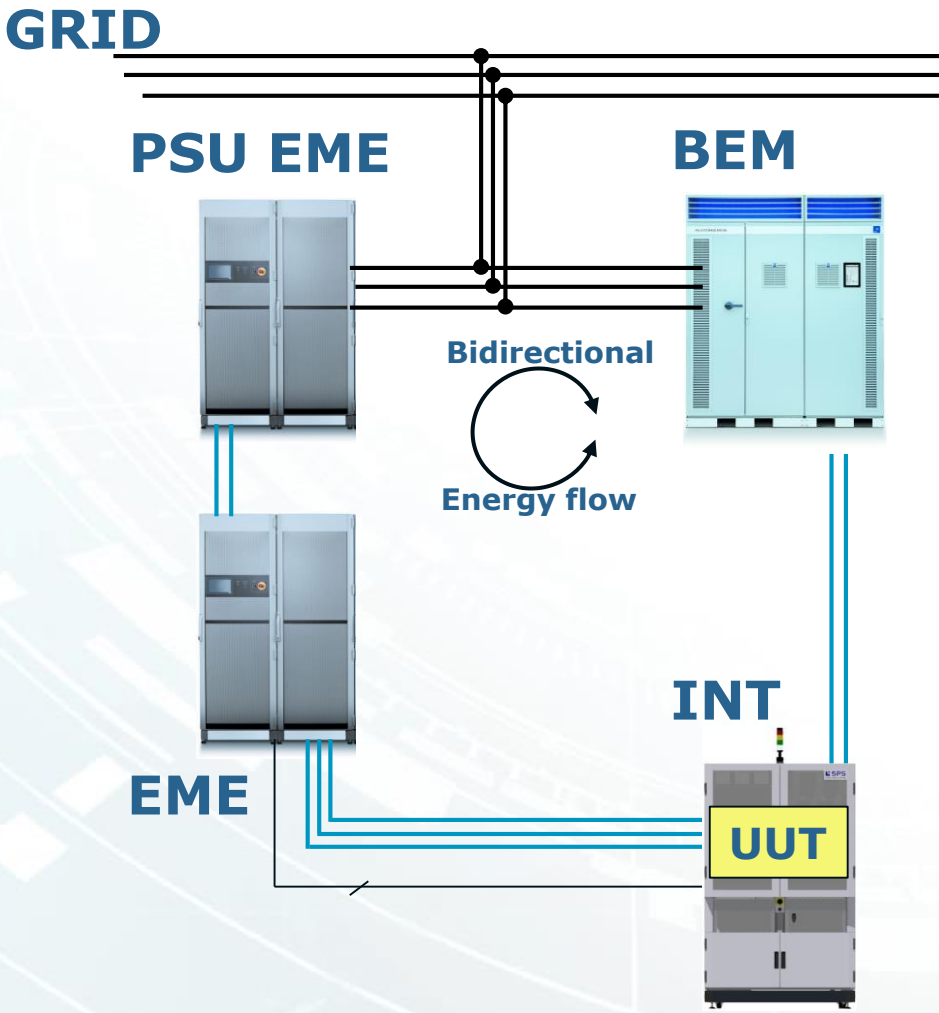
AC u v w

Power flow

E-Motor Emulator

Real Power & Signal flows

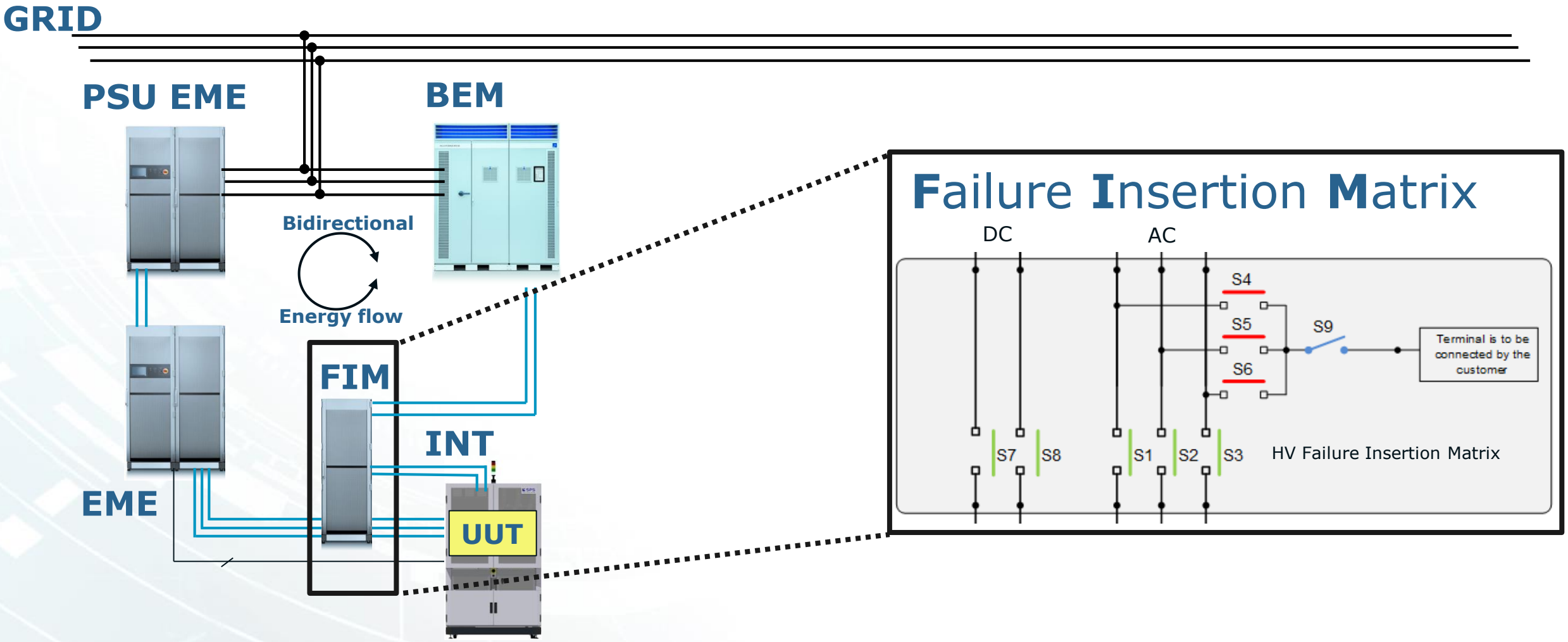
AVL Inverter Testbed : Power HiL based



EME = E-Motor Emulator
PSU EME = Power Supply EME
BEM = Battery Emulator
INT = INverter Table
UUT = Unit Under Test

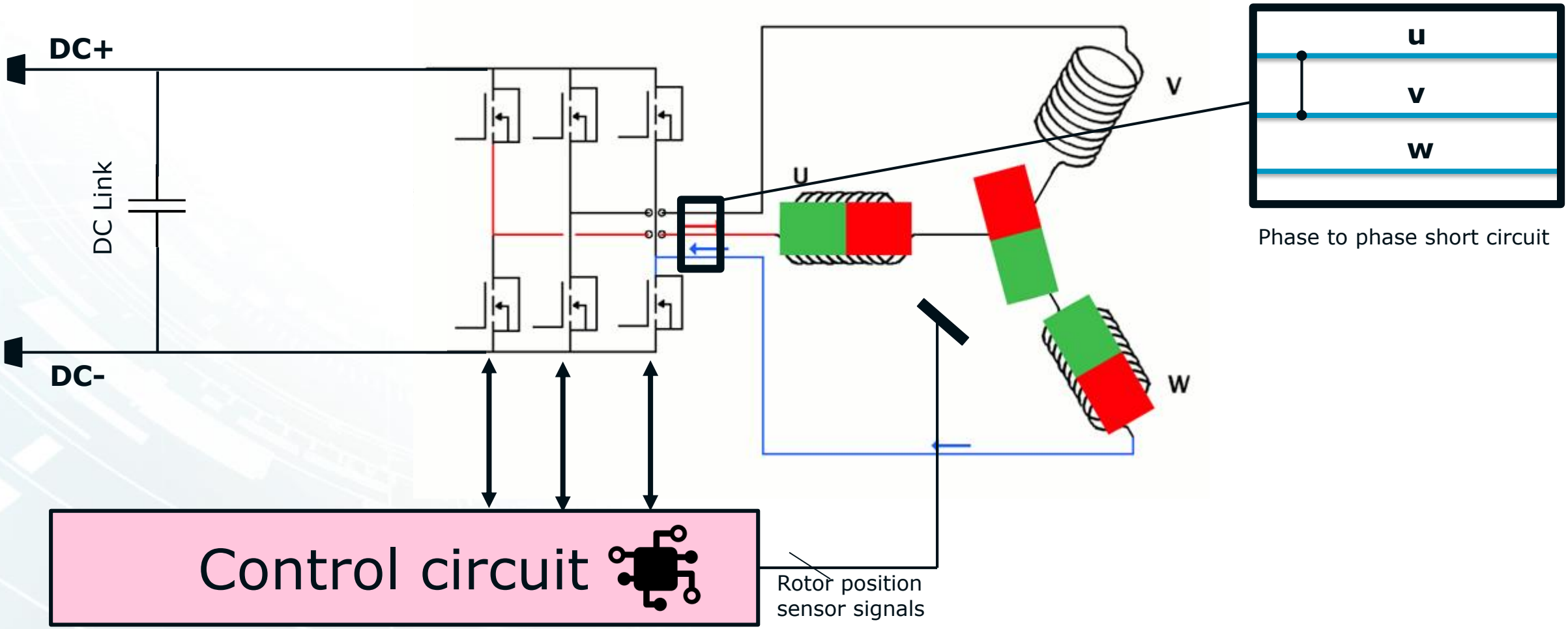

E-Motor Emulator 800A
Fault Insertion Matrix
E-Power Analysis
EME DC Supply
Coolant Conditioning System
Inverter Table
Battery Emulator
Automation System

AVL Inverter Testbed : Power HiL based



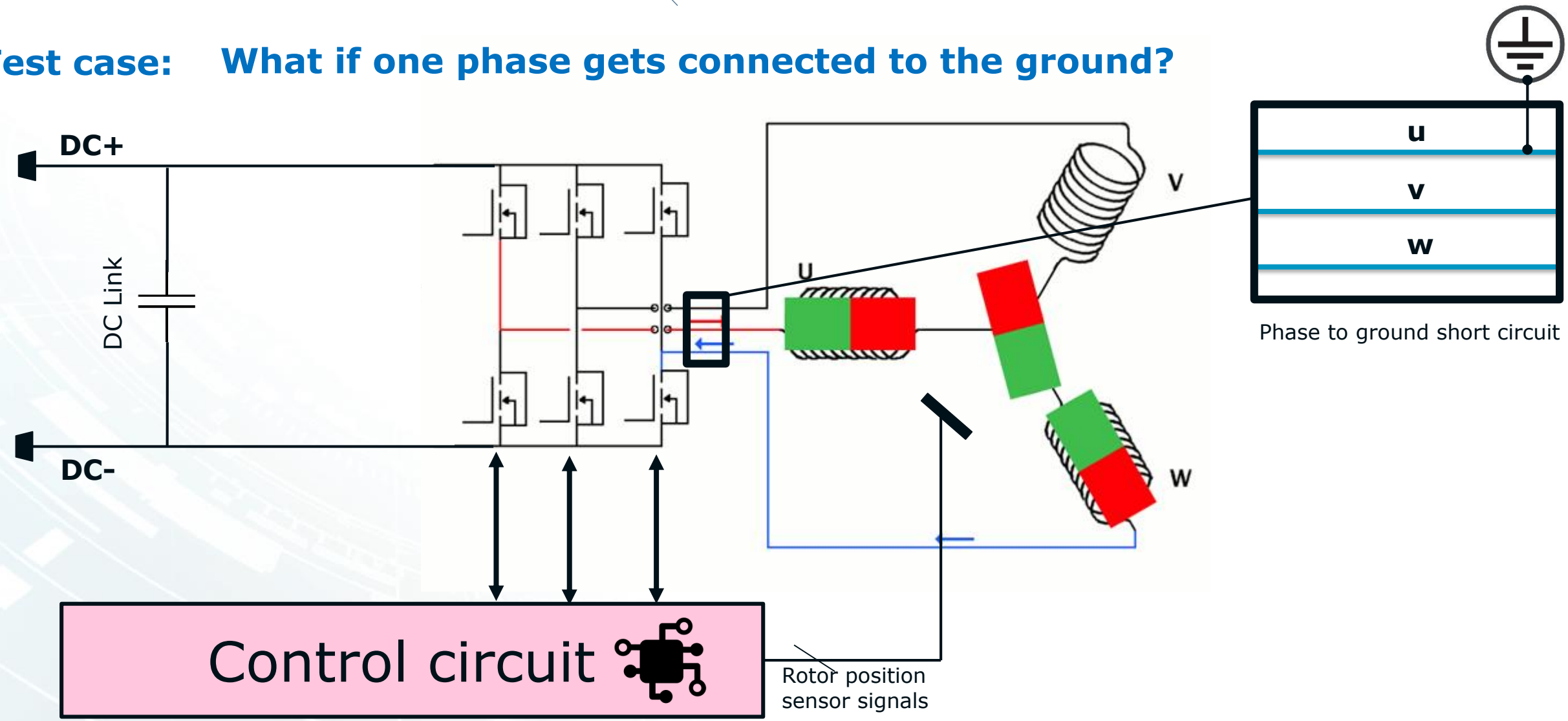
AVL Inverter Testbed : Power HiL based

Test case: What if the phases get short circuited?



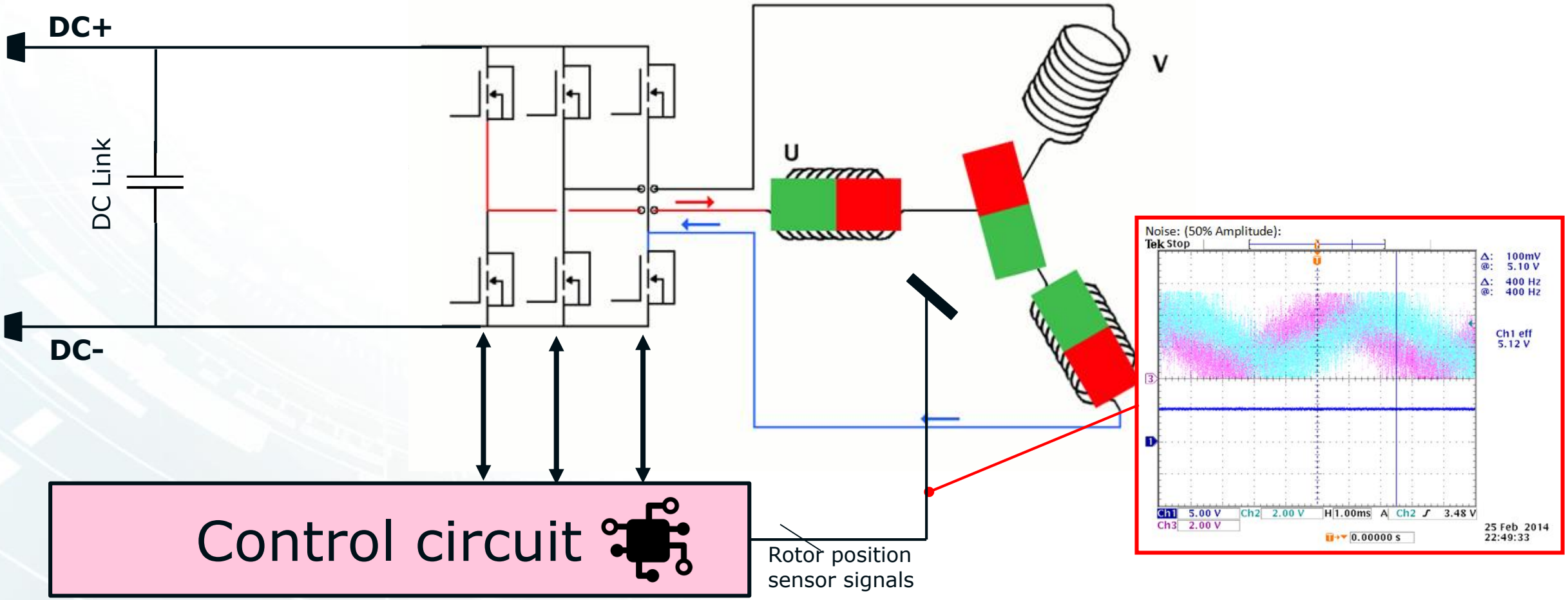
AVL Inverter Testbed : Power HiL based

Test case: **What if one phase gets connected to the ground?**



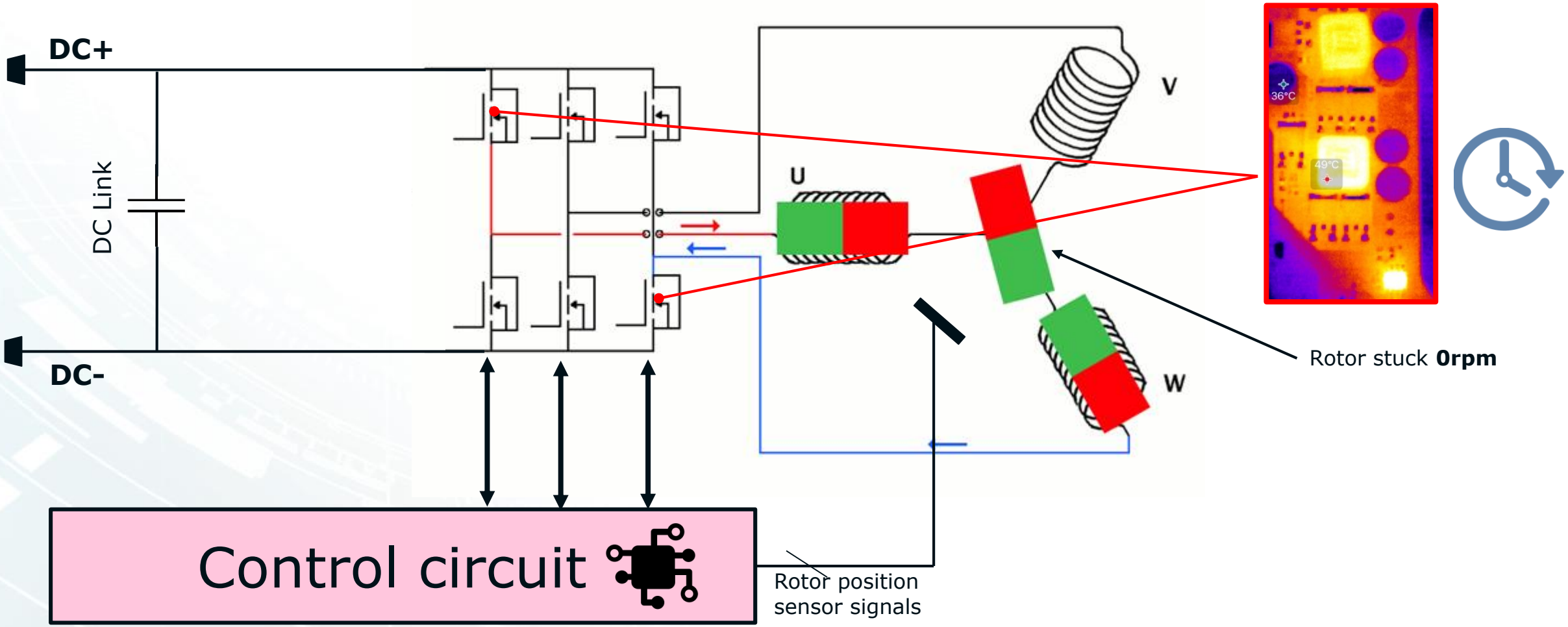
AVL Inverter Testbed : Power HiL based

Test case: What if the Rotor Signal gets noisy or lost?



AVL Inverter Testbed : Power HiL based

Test case: What if the Rotor is blocked for a long period of time?

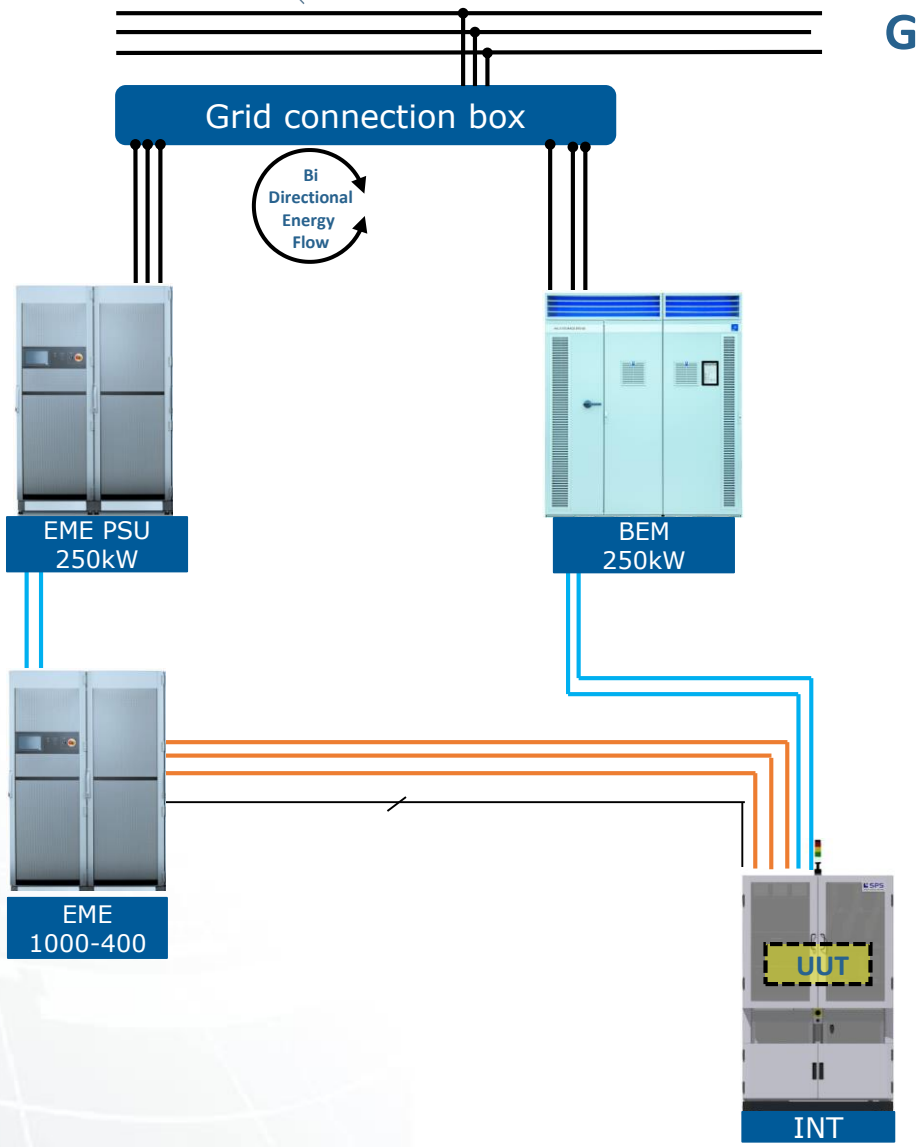


AVL Inverter Testbed : Power HiL based

Scalable solution:

Choose the maximum DC voltage

→ 600V | 1000V



EME – E-Motor Emulator	INT – Inverter Table
PSU – Power Supply Unit	UUT – Unit Under Test
BEM – Battery Emulator	TCM – Testbed Config. Matrix
FIM – Fault Insertion Matrix	CCH – Climatic Chamber

Grid
DC
AC
Signal

AVL Inverter Testbed : Power HiL based

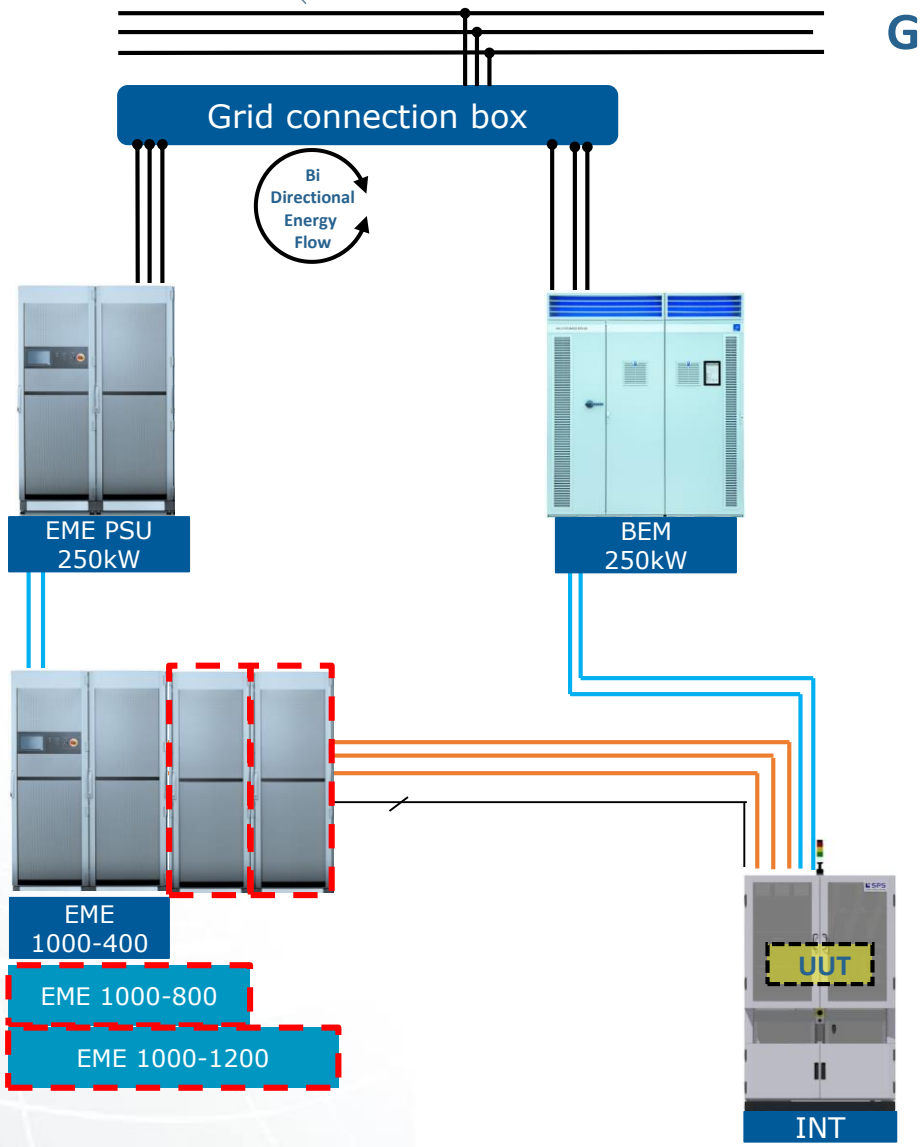
Scalable solution:

Choose the maximum DC voltage

→ 600V | 1000V

What is the maximum AC current?

→ 400Arms | 800Arms | 1200Arms … upgradable



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Scalable solution:

- Choose the maximum DC voltage
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- What is the maximum AC current?
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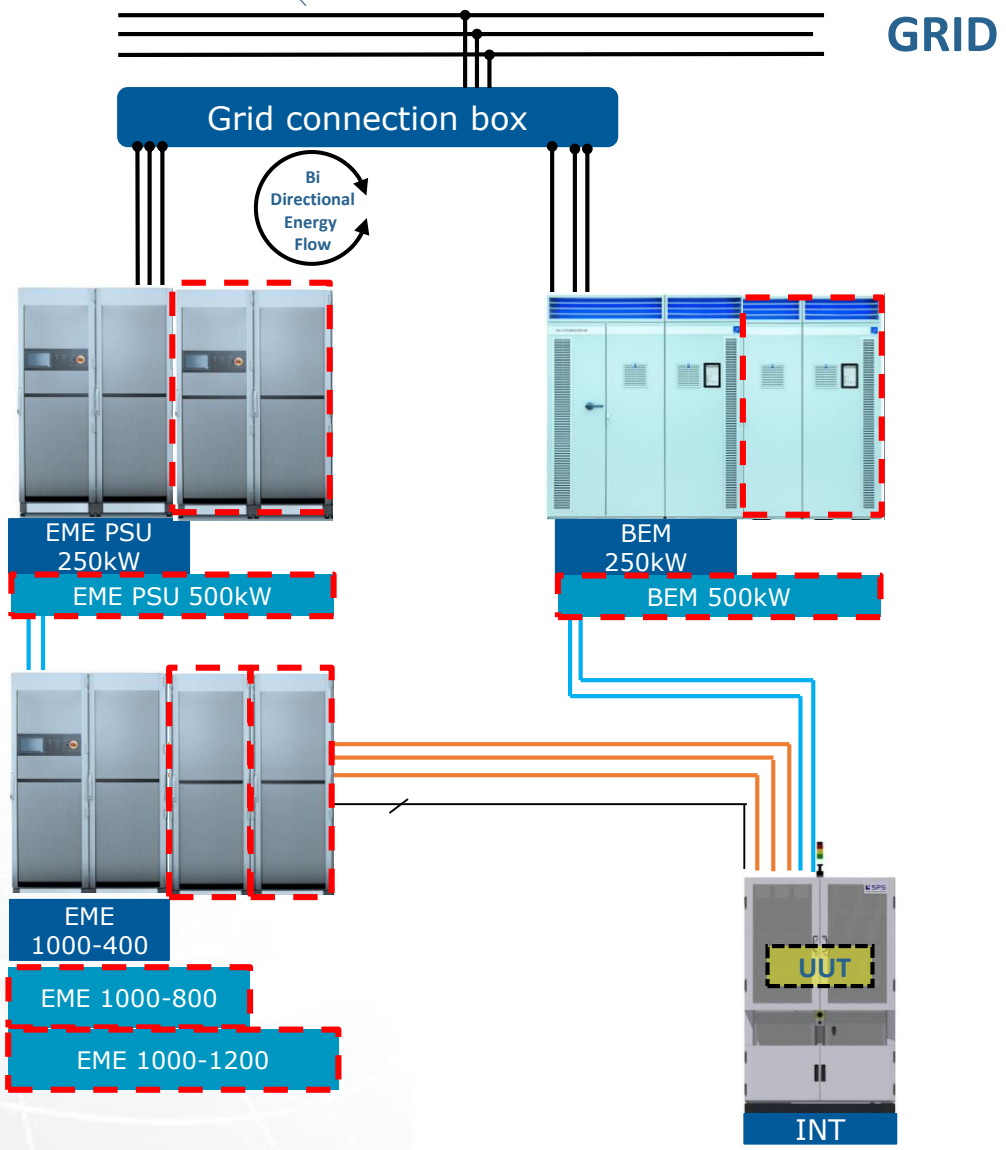
- What is the maximum power of the UUT?
  - → 250kW | 320kW | 500kW | 640kW … upgradable



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- Insertion of power fault needed?
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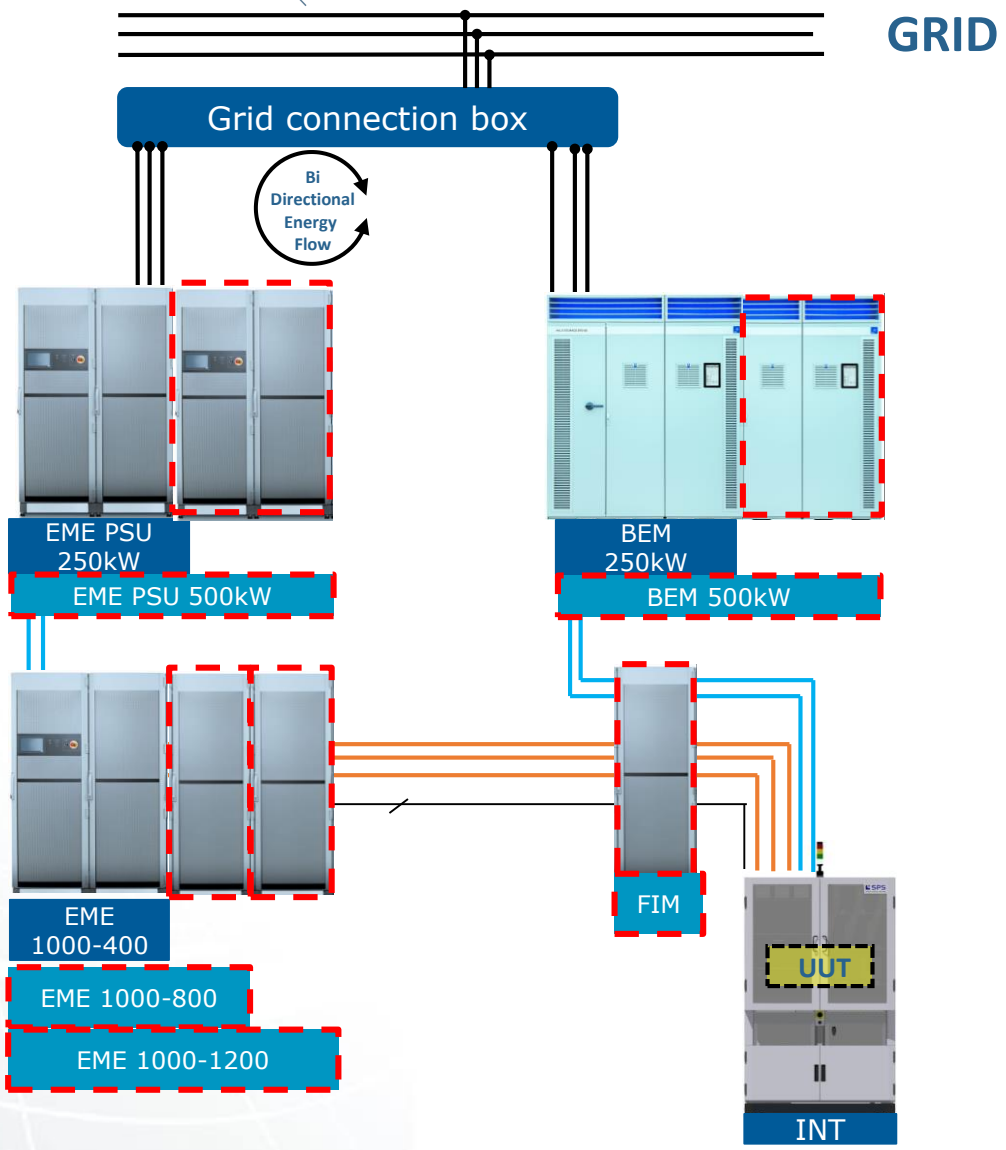

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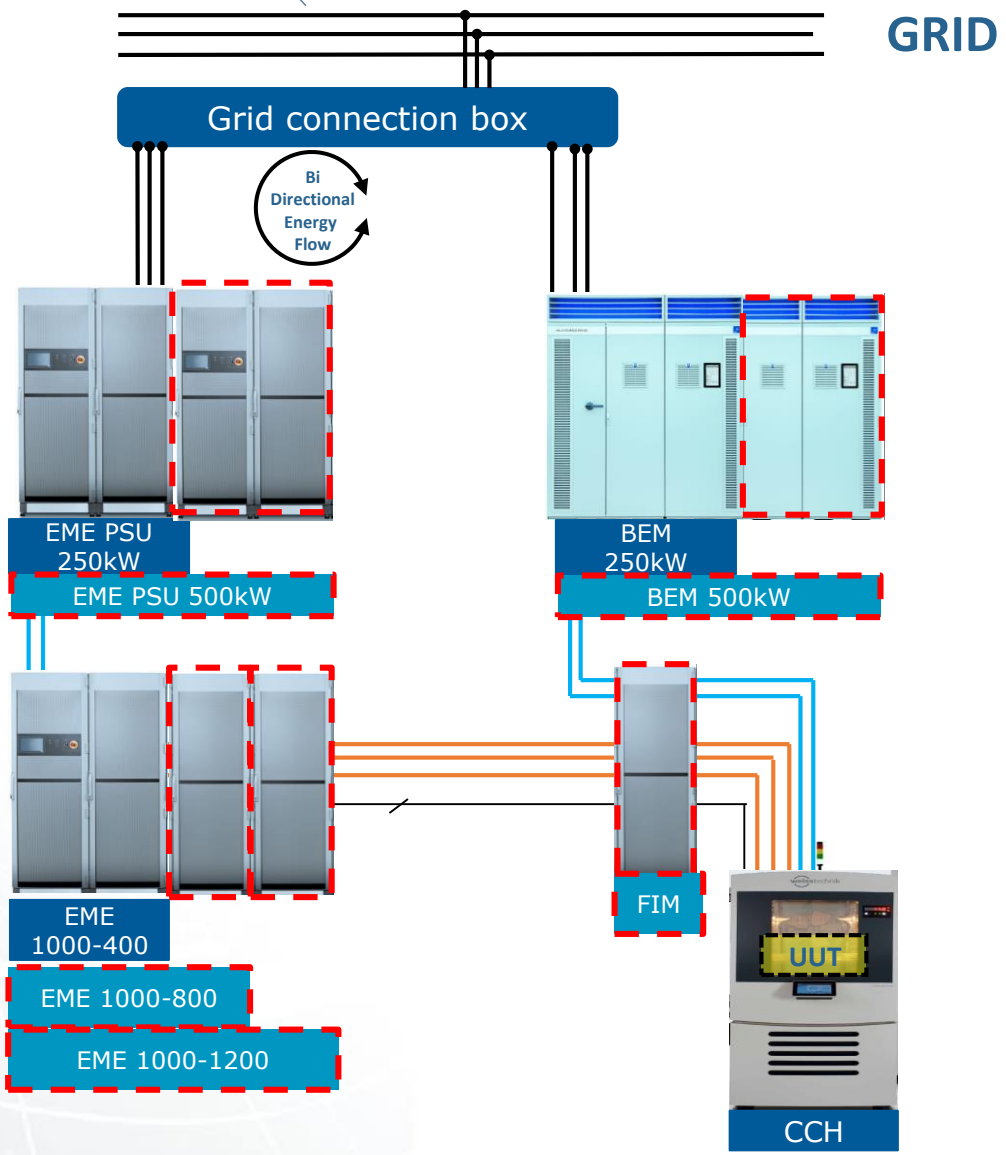
  - → FIM … upgradable
- Test under different climatic conditions needed?
  - → INV replaced by Climatic chamber … upgradable



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- Test under different climatic conditions needed?
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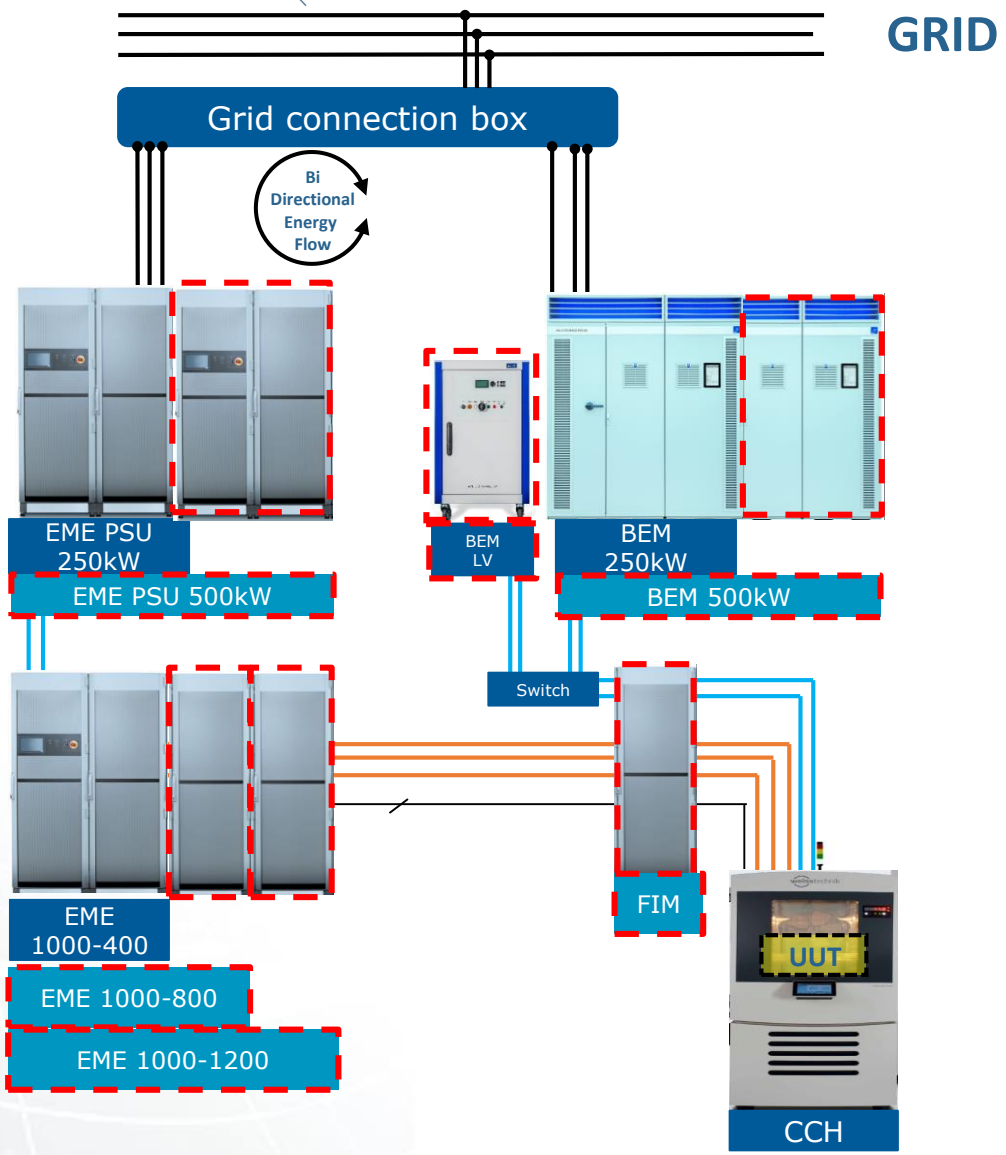
- 48V application?
  - → Add a LV eStorage … upgradable



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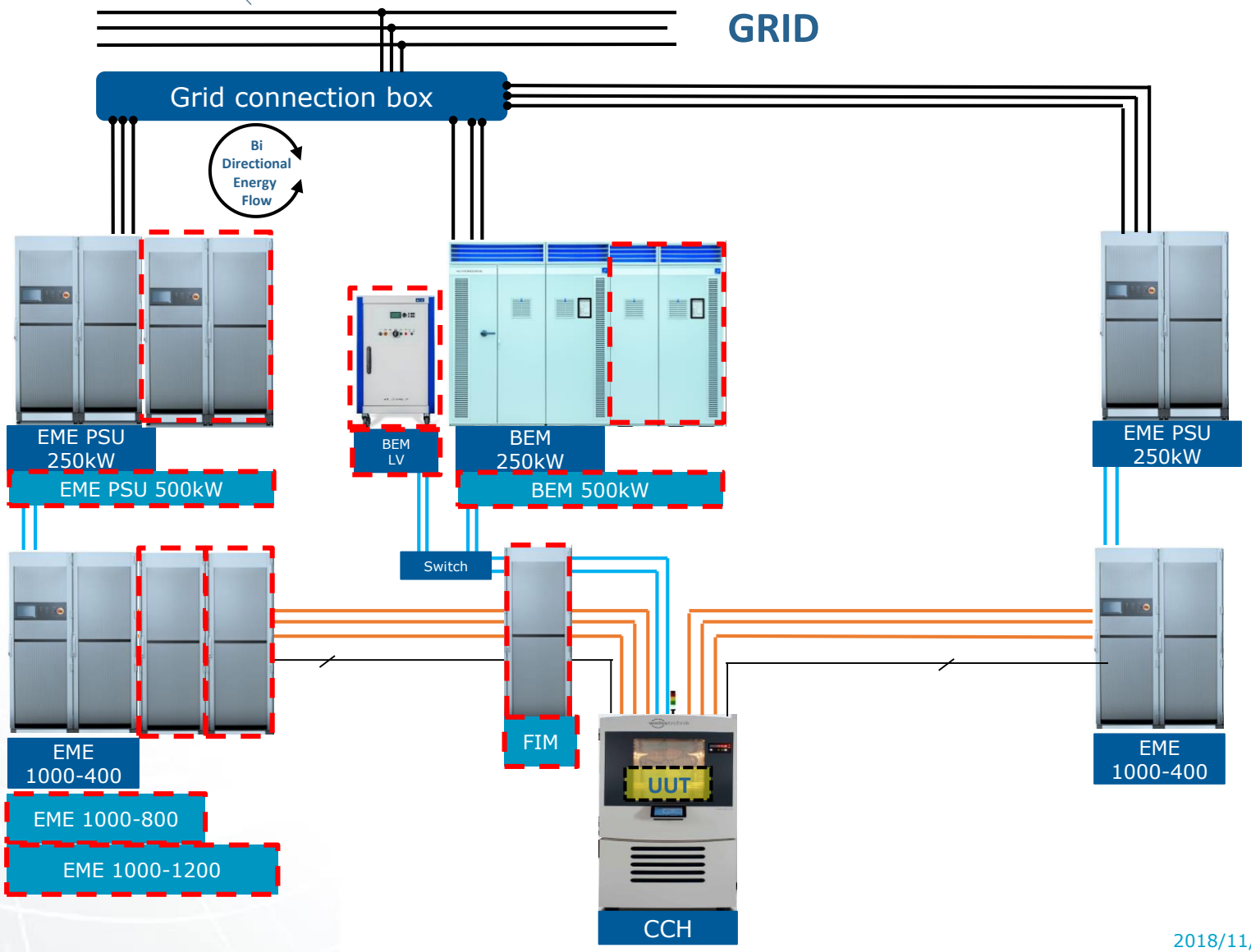
- Insertion of power fault needed?
  - → FIM … upgradable
- Test under different climatic conditions needed?
  - → INV replaced by Climatic chamber … upgradable
- 48V application?
  - → Add a LV eStorage … upgradable
- 6 Phase application?
  - → Add an EME … upgradable



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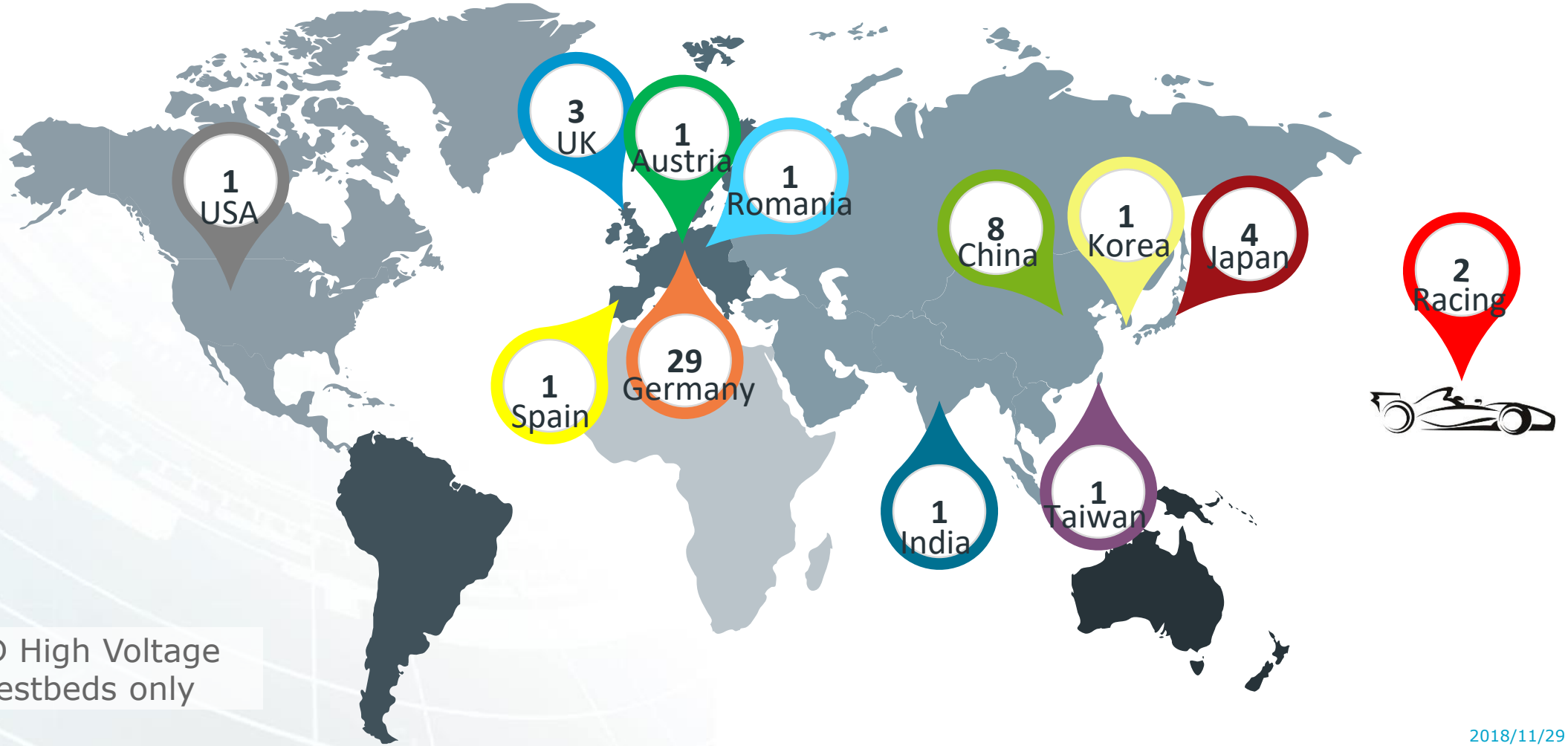
AVL Inverter Testbed : Power HiL based

Installed base:



Note: R&D High Voltage Inverter Testbeds only

AVL Inverter Testbed : Power HiL based

Summary of some advantages of the AVL inverter testbed architecture :

- The inverter is in the focus
- The test setup is independent from the eMotor
- The UUT is tested in its real power and signal environment
- The unknown variable of the environment are eliminated from the equation
- Allows testing fault in a safe and repeatable environment
- Upgradable concept (future-proof)
- The test coverage of the inverter is more complete and more efficient
- Proven solution

Thank you for your attention!