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Implementation and Dynamic Validation of an Adaptive Protection System in a Microgrid with Voltage Controlled Inverter

M. Nuschke
M. Valov

Contact:
maria.nuschke@iee.fraunhofer.de
Phone: +49 561 7294-257

Fraunhofer IEE
Königstor 59
34119 Kassel / Germany

www.iee.fraunhofer.de/en

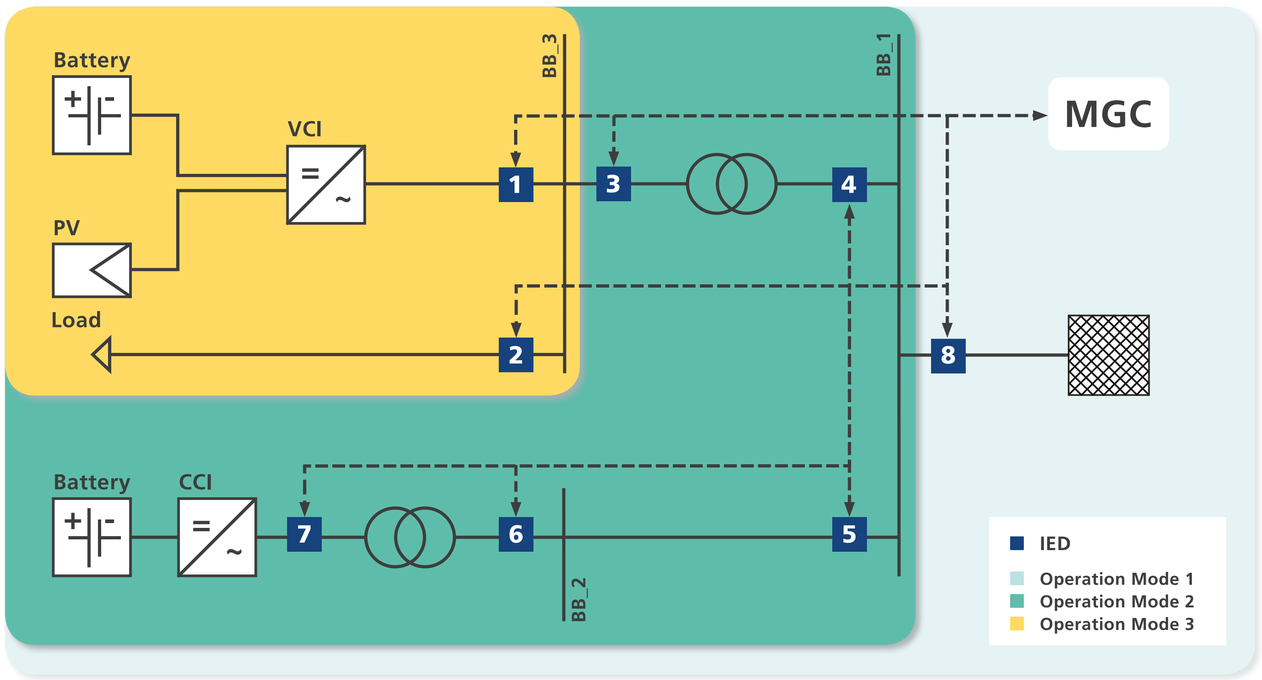

Figure 1: Single line diagram of the microgrid test system with different operation modes and communication signals for adaptive protection.

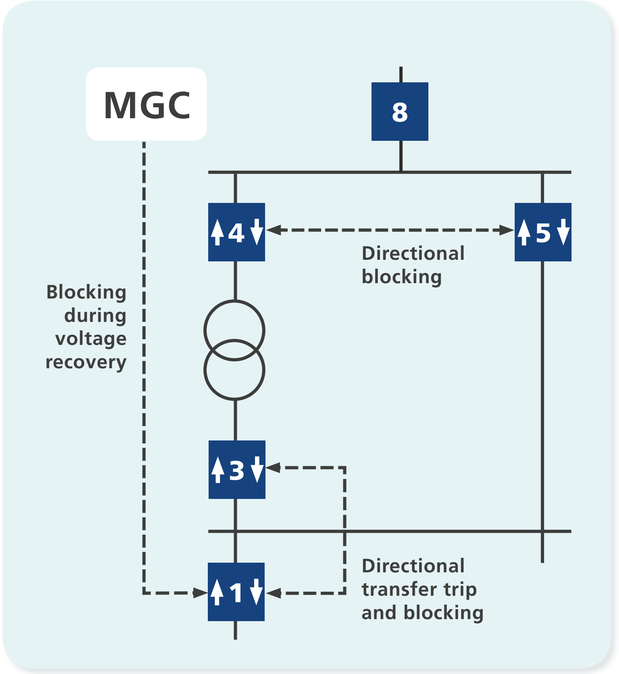

Figure 2: Application of transfer trip and blocking functions in the test system.

Microgrids are getting more attention – protection needs to be reconsidered!

- Grid forming inverters allow islanding operation without any synchronous generation. Flexible protection concepts are essential.
- Investigated test system consists of an aggregated load, a voltage controlled inverter (VCI) connecting PV and battery, and a current controlled inverter (CCI) for a battery.
- Possible operation modes:
  - 1 - Grid connected
  - 2 - VCI and CCI supply load in islanding operation
  - 3 - VCI supplies load in islanding operation
- A microgrid controller (MGC) updates protection settings of intelligent electronic devices (IED).

Impact of Inverter Based Grids on Protection

- Limited short-circuit contribution of inverters
- Black start capability of grid forming inverters
- Varying power flow directions
- Magnitudes of short-circuit currents tend toward load currents

Impact: Classical non-directional time-overcurrent protection with a single setting group becomes inadequate.

Enhanced Protection Concept

Proposed protection concept uses the potential of employed over-current relays and is enhanced with additional protective functions:

- Adaptivity
- Directional blocking
- Directional transfer trip
- Blocking during voltage recovery

Requirement: Communication infrastructure between IEDs and MGC but also among the IEDs for fast transfer and blocking signals.

Investigation Results and Conclusion

MGC identifies the prevailing operation mode and adapts the protection settings. Fig. 3 shows exemplarily the adjusted relay settings for the transition from operation mode 1 to 2.

Automatic adaption of relay settings combined with the utilization of directional over-current IEDs and additional protective functions increase dependability and selectivity of protection systems. Flexible and reliable operation of microgrids can be enabled!

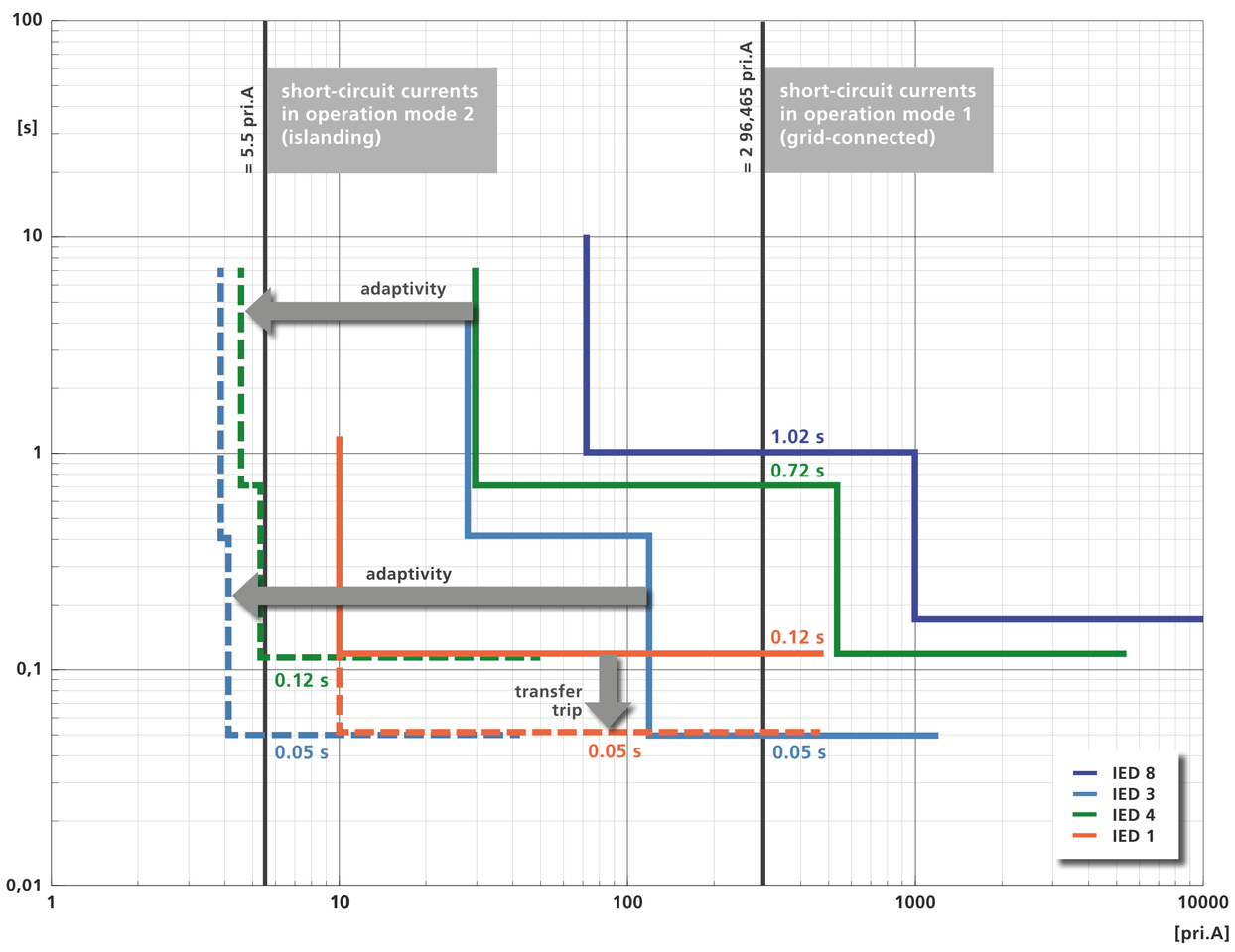

Figure 3: Tripping curves of the protection relays for a fault at BB_3 in operation mode 2 (islanding) with unchanged settings as in grid-connected mode (solid lines) and with adapted settings and enhanced functions (dashed lines).

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