

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

M. Valov  
M. Nuschke

Contact:  
maria.valov@iee.fraunhofer.de  
Phone: +49 561 7294-296

Fraunhofer IEE  
Königstor 59  
34119 Kassel / Germany

www.iee.fraunhofer.de/en

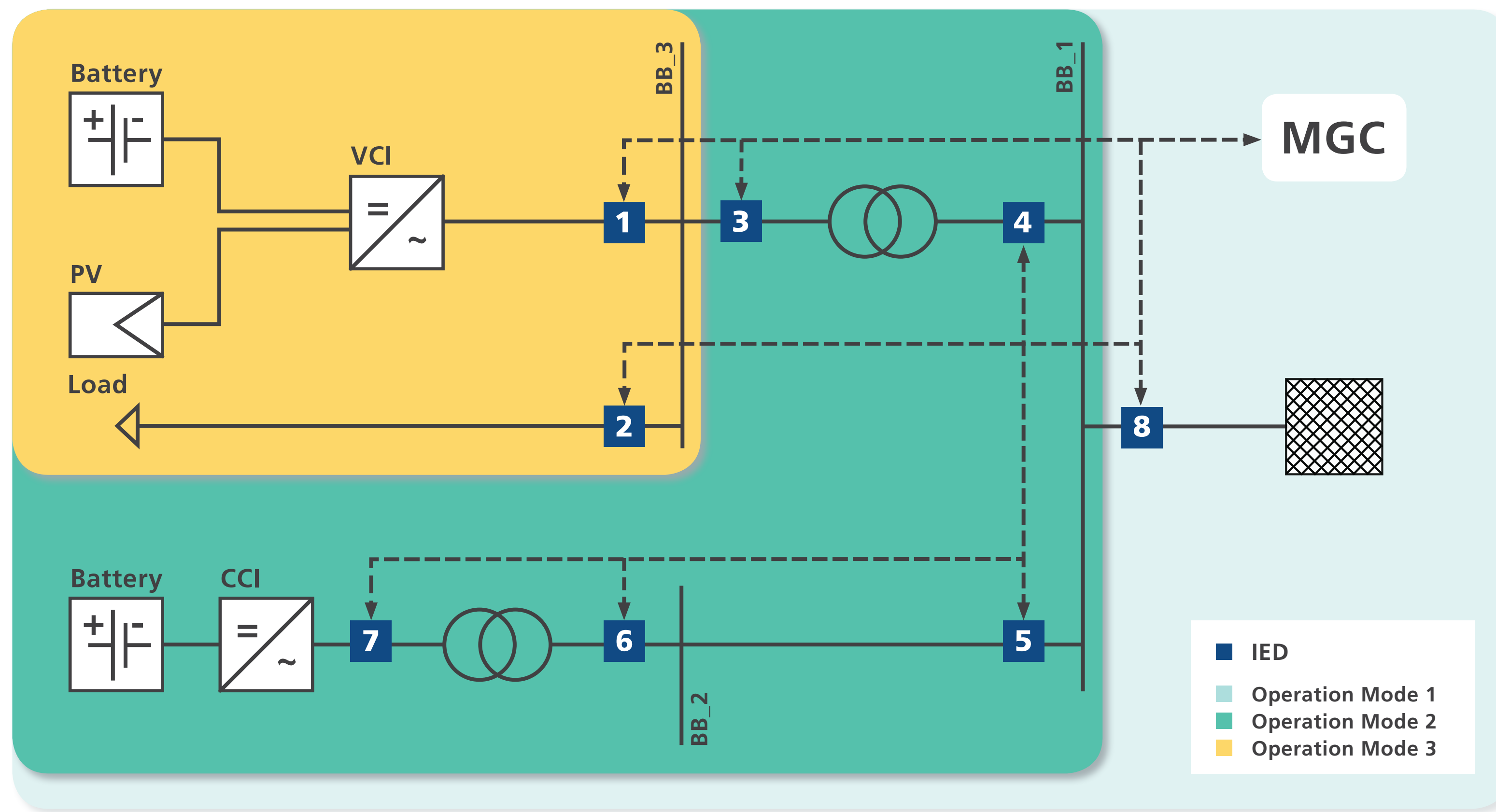


Figure 1: Single line diagram of the microgrid test system with different operation modes and communication signals for adaptive protection.

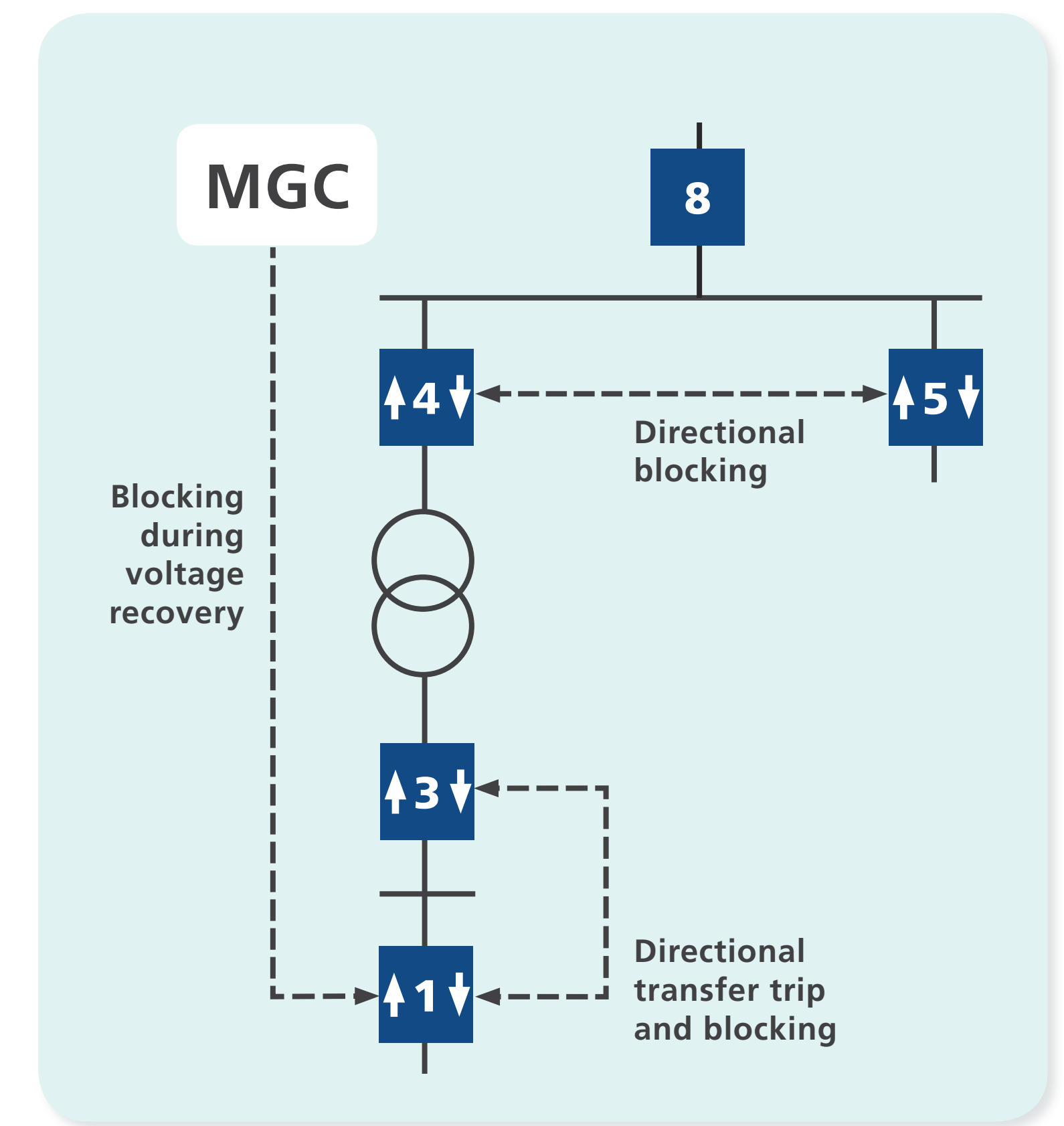


Figure 2: Application of transfer trip and blocking functions in the test system.

## 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 a static 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).

## 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!

## 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.

Supported by:



on the basis of a decision by the German Bundestag

We acknowledge the support of our work by the German Ministry for Economic Affairs and Energy and the Projektträger Jülich within the project "NETZ:KRAFT: Netz-wiederaufbau unter Berücksichtigung zukünftiger Kraftwerkstrukturen" (FKZ 0325776A).

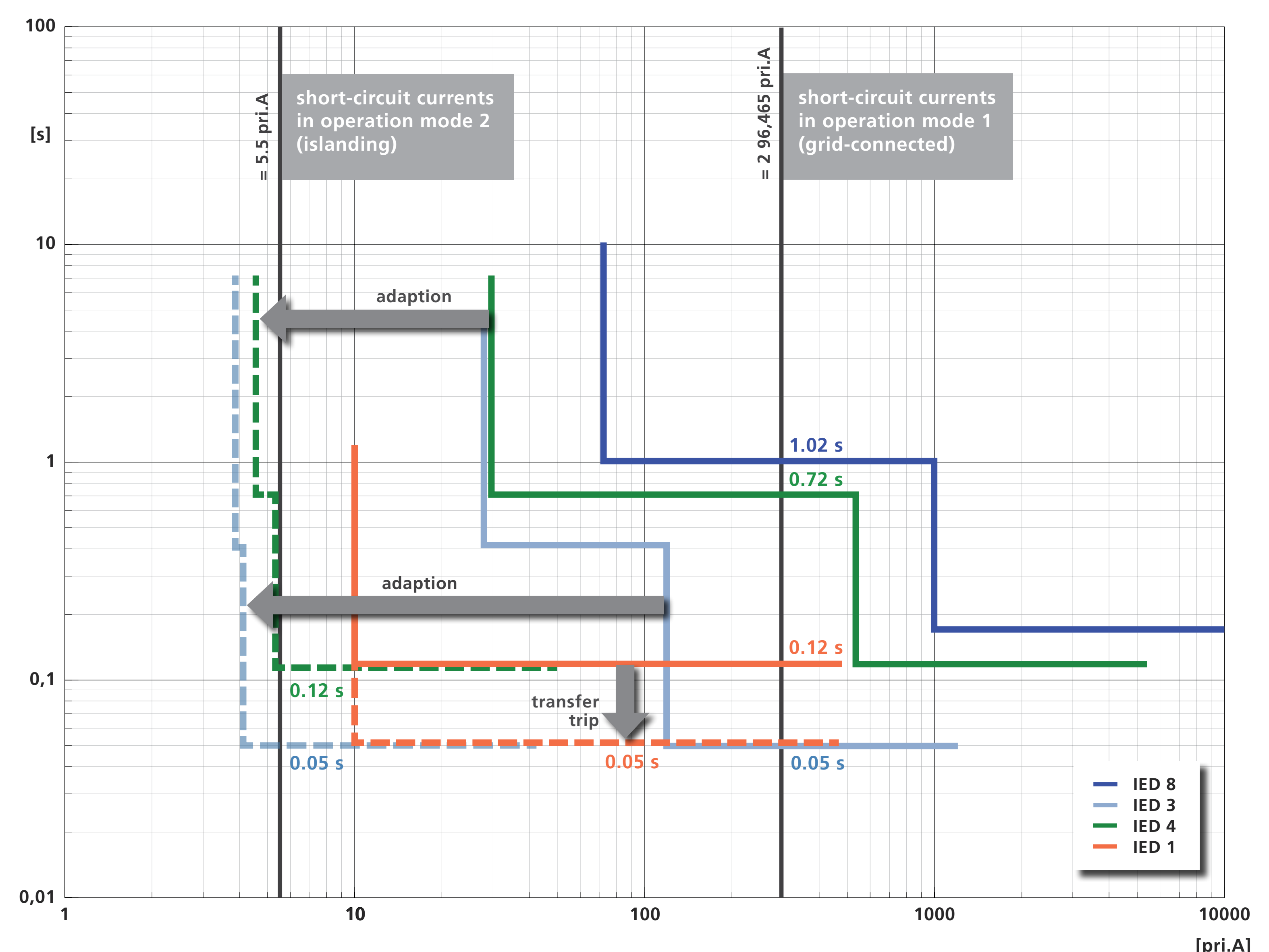


Figure 3: Tripping curves of the protection relays for a fault at BB\_3 in operation mode 2 (islanding) with unchanged settings as in grid-connected mode (solid lines) and with adapted settings and enhanced functions (dashed lines).