Presented at 2012 3rd IEEE PES ISGT Europe, Berlin, Germany, October 14 -17, 2012

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Microgrids: Building Blocks of the Smart Grid
Adaptive Protection Schemes for Microgrids

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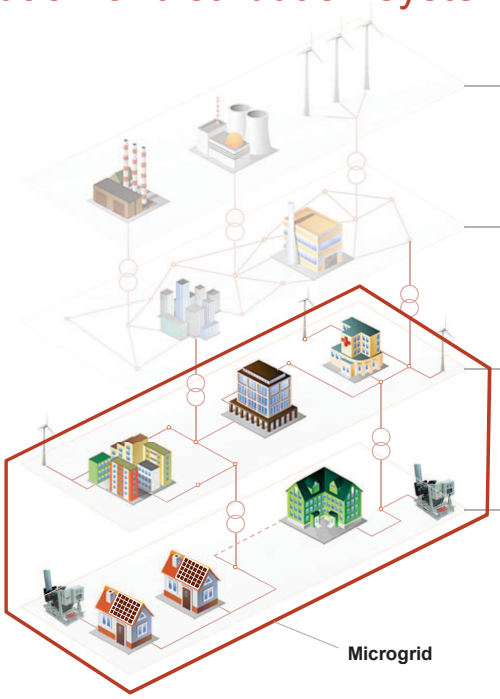
Active Protection for Microgrids
Outline

- Evolution of power distribution
- Protection issues in microgrids
- Adaptive protection solution
- Conclusions

Active Protection for Microgrids
Expected evolution of distribution system

Microgrids
are electricity distribution systems containing loads and distributed energy resources, (such as distributed generators, storage devices, or controllable loads) that can be
operated in a controlled, coordinated way either while connected to the main power network
or while islanded.

CIGRE C6.22 definition



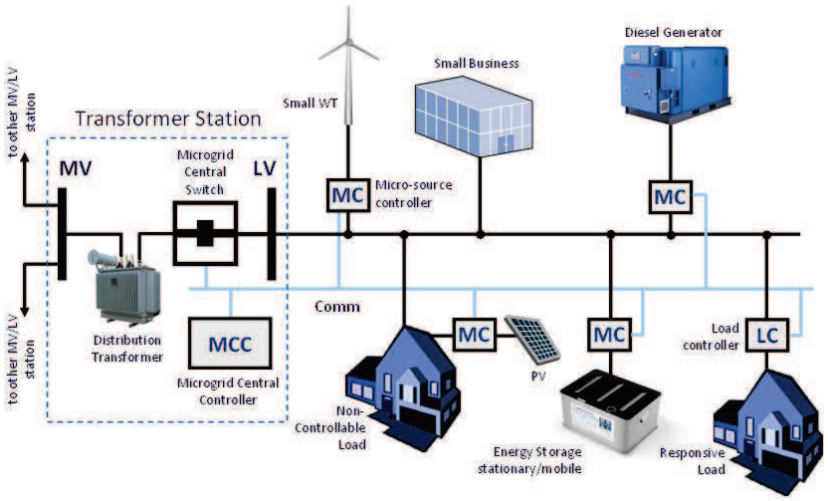
Central generation including renewables 50-25'000 MW

HV grid a backbone for long distance bulk power transmission at 110-1200 kV (AC or DC)

MV grid for a local power distribution at 6-35 kV
Distributed generation including renewables 1-25 MW

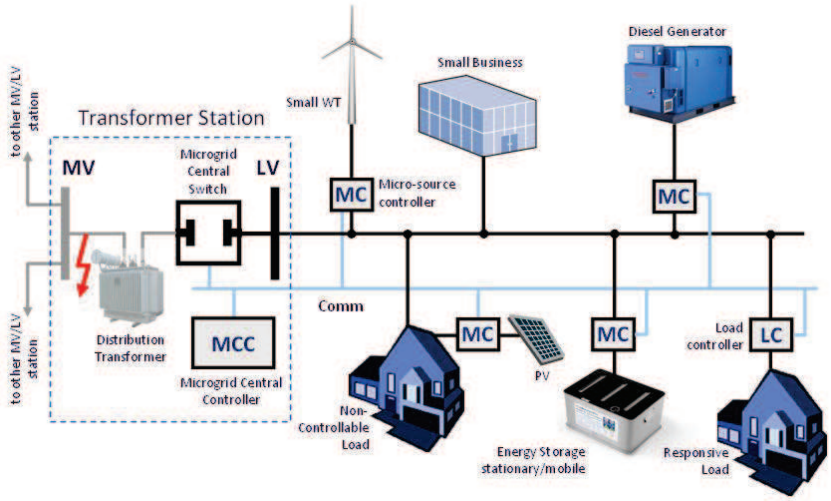
LV grid for the "last mile" power distribution at 110-1000 V
Sub-utility generation including renewables 0.005-1 MW

Active Protection for Microgrids
Grid connected and islanded modes



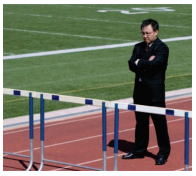
Protection must respond to both utility grid and microgrid faults
utility grid faults: protection isolates the microgrid from the utility grid as rapidly as necessary to protect the microgrid loads.
microgrid faults: protection isolates the smallest possible section of the radial feeder to eliminate the fault.

Active Protection for Microgrids
Grid connected and islanded modes



Protection must respond to both utility grid and microgrid faults utility grid faults: protection isolates the microgrid from the utility grid as rapidly as necessary to protect the microgrid loads. microgrid faults: protection isolates the smallest possible section of the radial feeder to eliminate the fault.

Active Protection for Microgrids
Some implementation challenges



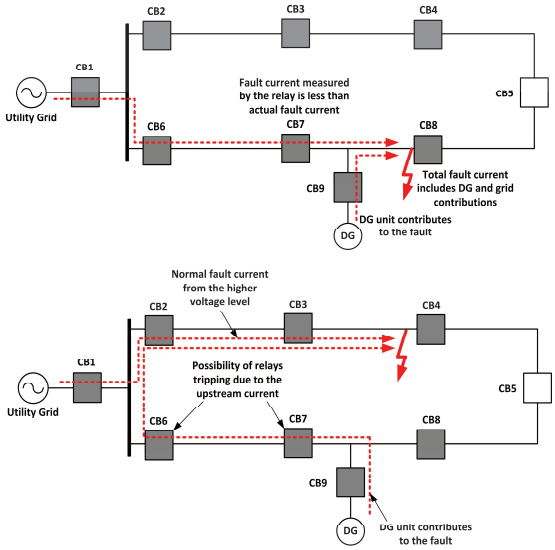
- Regulatory
- Technical
- Economic

- Control
- Protection
- Forecast
- Network planning

- Fault levels
- Fault Ride Through
- Coordination (setting management)
- Fault detection in islanded operation
- Automatic re-closing

Active Protection for Microgrids
Protection issues caused by DER

- Changes in the magnitude and direction of short circuit currents (DER on/off, network configuration incl. islanding)
- Reduction of fault detection sensitivity and speed in tapped DER connections
- Unnecessary tripping of utility breaker for faults in adjacent lines due to fault contribution of the DER
- Auto-reclosing of the utility line breaker policies may fail



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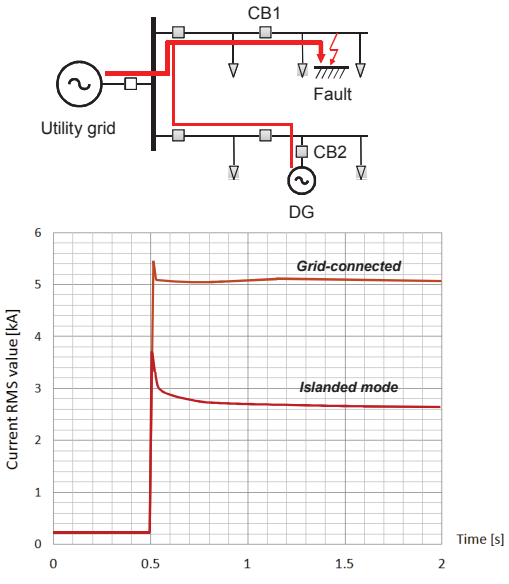
Protection issues in the islanded operation

- In the grid connected mode the utility provides a significant fault current during the fault
- After isolation from the utility grid the local generator (DG) is the only fault current source in the island
- Fault current level depends on type, size and location of DG but it is lower than the fault current from the utility grid
- CB1 operation will be delayed and if the time delay exceeds a limit of DG under voltage protection CB2 will disconnect DG unit and the island will be shut down

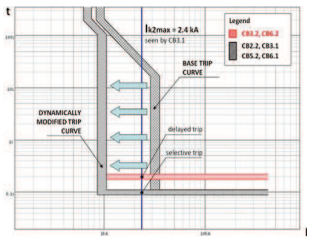


Active Protection for Microgrids
Novel protection strategies

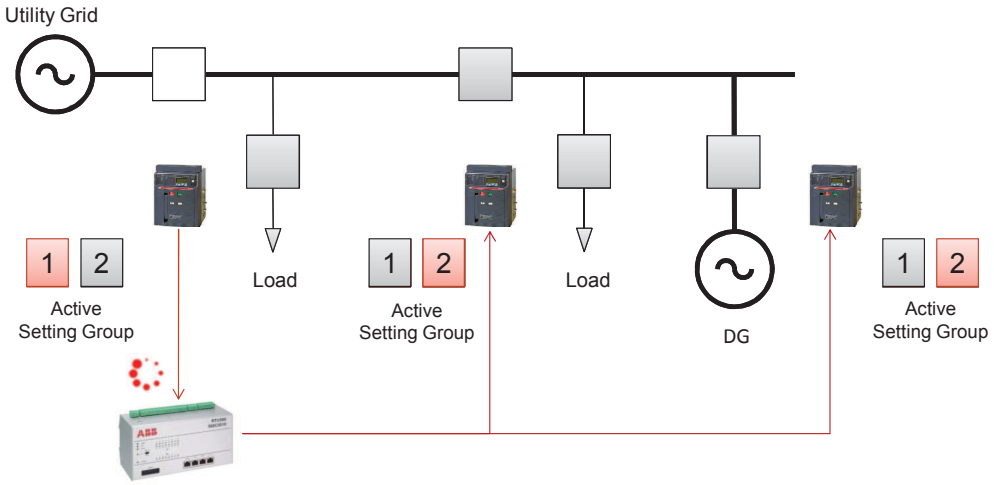
- Novel protection strategies ideally will be generic such that they could be:
  - applicable for both grid and islanded operation
  - adapted to any DER type and penetration level
  - scalable so that the strategy does not need to be redefined with each new DER connection
- May include requirements for:
  - dynamic protection settings management for protection coordination
  - modifying or replacing protection devices
  - use of advanced protection functions

Active Protection for Microgrids
Dynamic protection settings management

- Adjusts protection settings to the actual state of the active distribution network (DER, feeder) based on the preset logic
- Accomplished by monitoring of actual protection settings and DER/network connectivity
- A programmable logic application is called to perform after changes in circuit breaker status
- Suggestions for practical implementation:
  - Use of IEDs with directional over-current protection function and with multiple setting groups
  - Use of communication infrastructure and standard protocols to exchange information between IEDs and a central controller (e.g. RTU)

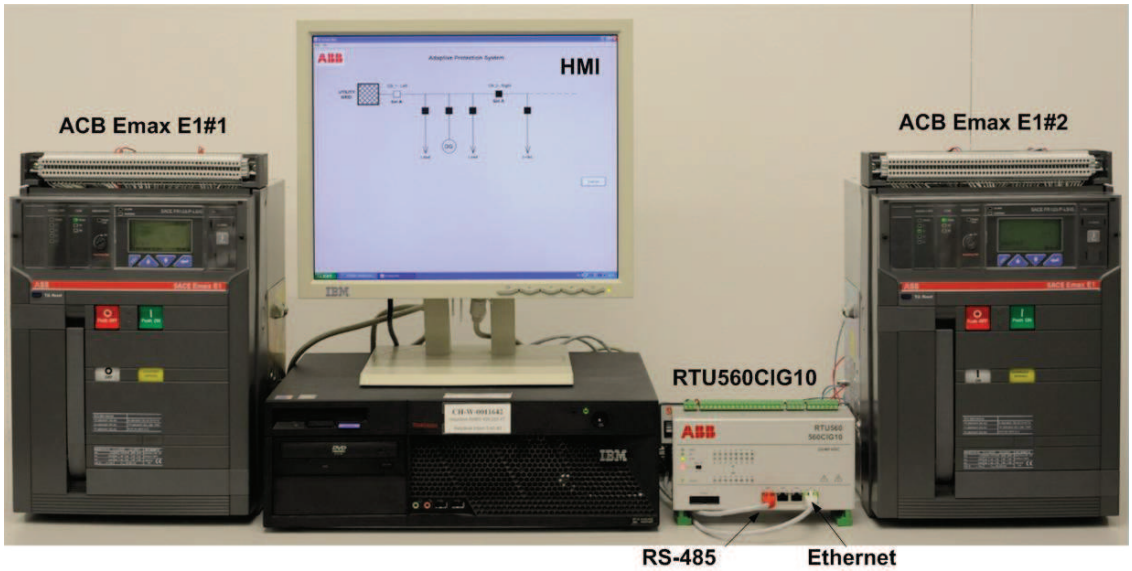


Active Protection for Microgrids
Active Protection Concept



- RTU periodically reads the status of selected circuit breakers and actual setting group via Modbus-RTU
- When the CB status change is detected the RTU analyzes if the change of active setting group is needed by using programmed logic
- RTU sends the Modbus command to switch the setting group in CBs to keep the sensitivity of the relay to the faults in the islanded mode

Active Protection for Microgrids
Active Protection Concept



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Conclusions

- High penetration level of DER and isolated operation pose main protection challenges in microgrids
- Ideally protection system must follow the network topological changes and connectivity of DER in the microgrid
- Adaptive protection system switches between the pre-calculated “trusted” setting groups based on the actual operating state of the microgrid using standard communication and programmable logic
- Adaptive protection may increases availability of local generation and reduces outage time for the customers without a need to change existing hardware

Active Protection for Microgrids
Further reading

- A. Oudalov, A. Fidigatti, “Adaptive Network Protection in Microgrids”, International Journal of Distributed Energy Resources, Vol.5, No.3, pp.201-226, July-September 2009
- A. Oudalov, L. Milani, E. Ragaini, A. Fidigatti, “Sample Implementation of Adaptive Protection for Low Voltage Networks”, PAC World Magazine, Vol.20, pp.28-33, June 2012

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