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Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

TABLE OF CONTENTS:

1. INTRODUCTION

This summary report very briefly describes the activities in work package 2.2 “New protection relay applications”.

2. TRADITIONAL DISTRIBUTION PROTECTION

The impacts of DG relate to the sensitivity and selectivity of typical network protection. Due to the presence of DG, some faults may be detected with significant delays or, in the worst case, not detected at all. On the other hand, unnecessary relay operations are possible on feeder relays or at the DG connection point. The difficulty of detecting unintended island situations makes the situation even more complex. The most important challenge is thus differentiating between faults that require action and other disturbances. In this work package new solutions using distance protection and fast communication have been analyzed and demonstrated.

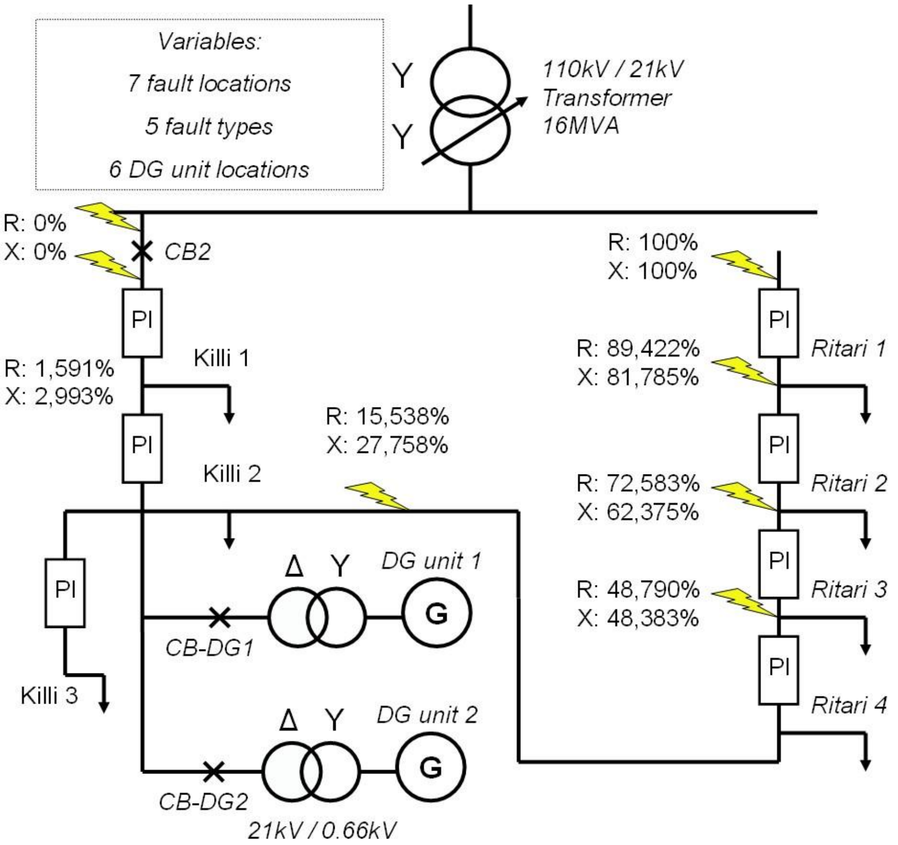
3. DISTANCE PROTECTION

The simulation studies consisted totally of eight cases. In the first two cases there was no DG included and their purpose was to enable more detailed performance comparisons with the cases where DG was involved. Also without any DG-effects it was easier to ensure and verify that the IED was correctly configured and set. In all other cases two synchronous generators each rated to 1.36 MVA were connected to different locations and distances from the substation as follows:

- Case 1 – No generation in the feeder
- Case 2 – No generation nor loads in the feeder
- Case 3 – The DG units were located at Killi 1
- Case 4 – The DG units were located at Killi 2 (the same node as Ritari 4)
- Case 5 – The DG units were located at Ritari 3
- Case 6 – The DG units were located at Ritari 2
- Case 7 – The DG units were located at Ritari 1
- Case 8 – The DG units were located at the end of the feeder

In each of the above cases five different fault types were tested in seven different fault locations which can be seen in Figure below. The fault types in each case were the following:

- Single-phase-to-earth fault with zero fault resistance
- Single-phase-to-earth fault with fault resistance
- Two-phase-to-earth fault with zero fault resistance
- Phase-to-phase short circuit fault
- Three-phase short circuit fault



From the results and IED measurements it can seen that DG-infeed causes errors to the measured impedance at the beginning of the feeder which can result to either over- or underreach depending on the DG location. Whereas in case of overcurrent scheme the DG-infeed decreases the measured fault current from the beginning of the feeder compared to the case where DG is not connected. Despite these effects both the distance and overcurrent scheme operated correctly in all test cases with the selected setting values. This applies to the selectivity of operation and to the operating times of the functions. To ensure correct operation of protection the above effects must be evaluated case by case and taken into account when selecting the setting values for the functions.

Regarding the operating times the distance scheme can generally be set to operate faster than the overcurrent scheme without endangering the security of the protection. Typically the operation of overcurrent protection must be delayed adequately to override e.g. switching inrush current and cold load phenomena to avoid false operations. In this sense the operation of distance protection is highly stable, as equivalent load current of approximately 1.5-4 times the low-set overcurrent setting depending on the phase angle is required to activate the zone 1 of the distance scheme, provided that in the same time the voltage stays at its nominal value.

The effect of fault resistance (arcing faults) on the operation of short circuit protection was not tested. Evidently this reduces the fault current even more and this may cause sensitivity problems for the overcurrent scheme. This is also the case if higher start current setting would have been used for the low-set stage due to increased load of the feeder. As a result, faults in the furthest locations in the feeder may not have been detected reliably by the overcurrent scheme. Whereas in the distance scheme the effect of possible fault resistance can be taken into account by a dedicated resistive reach-setting which ensures the dependable operation also in these cases.

4. NETWORK AND GENERATOR PROTECTION USING FAST COMMUNICATION

With fast communication with advanced IEDs it is possible to disconnect DG quickly when needed, e.g. when fault is in the generator feeder or on the substation. At the same time it is possible to block generator protection when fault is located on another zone providing fault ride through (FRT) capability.

The main results are shortly presented in the leaflet in Appendix 1.

APPENDIX 1: LEAFLET OF ADVANCED GENERATOR LOSS OF MAINS PROTECTION

Attached is the leaflet of generator loss of mains protection.

Acrobat Document

Loss of Mains Protection Issues

Unintentional islanding is not allowed in distribution networks due to a number of reasons:

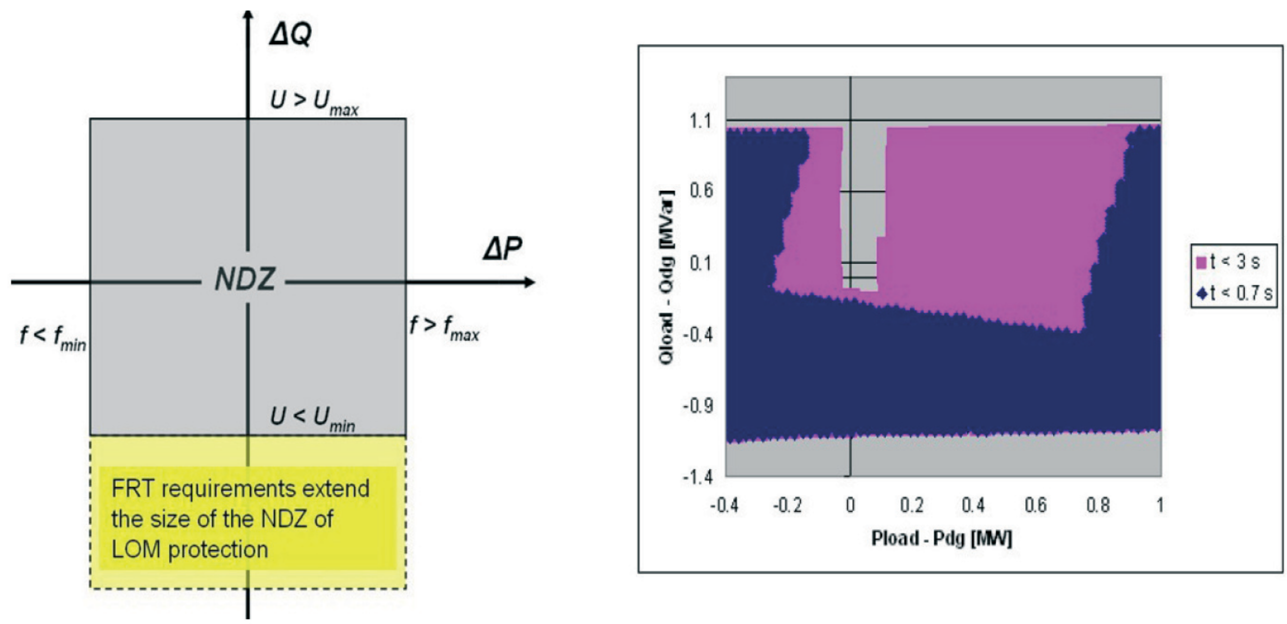
- Safety hazards for repair crews
- Potential risks of components being damaged
- Unintentional islanding can cause autoreclosing failures

Because of these reasons, it is obligatory that all DG units are equipped with a LOM relay which ensures that unintentional islanding does not occur.

The most utilized LOM detection methods fail to detect islanding when the production matches closely with the consumption in the islanded zone. This blind area is called the non detection zone (NDZ). The size of the NDZ can be reduced by tightening the LOM relay settings but it may cause unwanted tripping. Stricter settings are also problematic in the sense that DG should support the power system during voltage dips (Fault ride through (FRT) requirements).

Many protection studies including real protection relays have been carried out with the help of a real time digital simulator (RTDS) in the ADINE project:

- The functioning of autoreclosing in a network including DG
- The contradiction between FRT and LOM protection
- The determination of the NDZs of various LOM protection functions
- Testing of a specific communication based LOM protection method by ABB



The left figure illustrates how fulfilling the FRT requirements extends the size of the NDZ due to the necessity of loosening undervoltage protection setting of the LOM relay. The right figure, which shows the form of the NDZ of a real LOM protection relay, was determined based on a myriad number of simulations which were carried out with the help of a real time digital simulator (RTDS).

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ENHANCED LOM PROTECTION WITH FAST COMMUNICATION

The Adine project has demonstrated substantial benefits in generator protection using fast communication between IEDs. The communication uses both standard IEC 61850 GOOSE messages and user definable signals using Binary Signal Transfer (BST) that RED 615 IED offers.

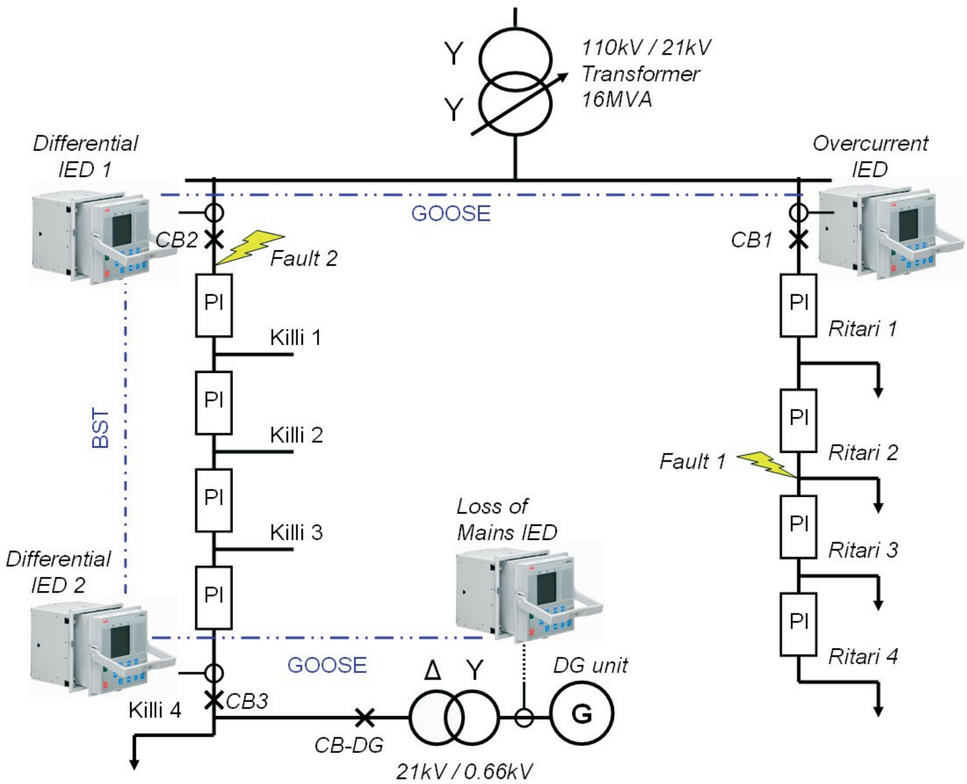
RESULTS

- Fast tripping of generator when the fault is in the generator feeder or on the substation
- Securing FRT when the fault is on the other feeders

DEMONSTRATED CASES

Fault in location Fault 1 causes a voltage dip. IED of CB1 trips and sends block as a goose message to IED of CB2. IED of CB2 sends the message via BST to IED of CB3. IED of CB3 sends the block message to LOM IED as a goose message.
-> DG unit was not disconnected

In case of Fault 2 overcurrent protection in IED of CB2 trips and sends a command using BST to IED of CB3. This IED sends trip message to LOM IED.
-> DG unit was disconnected without unnecessary delays.



The demonstration network model having two feeders and 4 IEDs utilizing GOOSE and BST messages.

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OSKE
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