

Smart Fuses for Smart Grids

Considerations about the need, potential product features and feasibility

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Smart Fuses for Smart Grids

■ ProFuDiS

The increase of decentralized energy generation leads to a lot of changes in electrical power networks and therefore also a lot of changes for the protection systems used in electrical LV- and MV-power networks.

The ProFuDiS project has the objective to identify requirements and solutions for existing and future protection systems.

■ Cooperating partners of ProFuDiS

RWTH Aachen University; FGH e.V.; HTW des Saarlandes University; RWE Deutschland AG; SMA Solar Technology AG; Omicron electronics GmbH; NH/HH-Recycling e.V.; ABB AG; Schneider Electric GmbH; Siemens AG;

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Smart Fuses for Smart Grids

- **Introduction**
- **Impact of distributed generation on low voltage grid protection**
- **Requirements and feasibility of smart fuses**

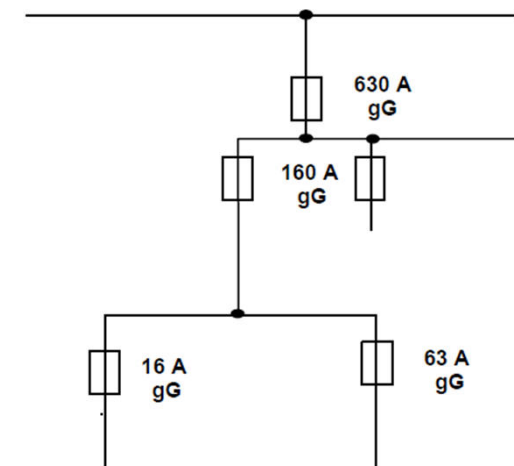
Smart Fuses for Smart Grids

Introduction

- Electric fuses
 - Current sensing protective device
 - Independent of the current direction
- Radial low voltage (l.v.) distribution grids:
 - gG fuses widely used for protection
 - Graded for selective operation
- Increasing number of Distributed Generation (DG)
 - Influence on the power flow (normal / **fault state**)

➡ Usability of „classical“ fuses needs to be checked

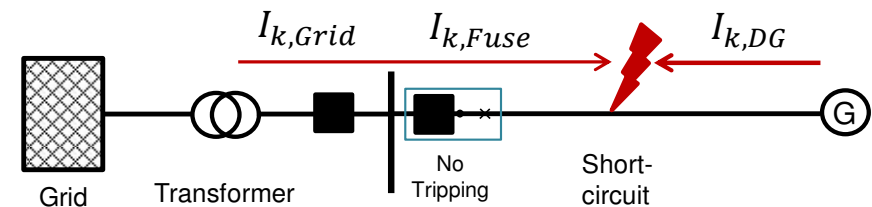
➡ „Smart“ fuses as an alternative approach?



Smart Fuses for Smart Grids

Impact of distributed generation on low voltage grid protection

- In case of grid faults:
 - DG contribution to the fault current
 - Rise of the potential at the point of common coupling (PCC) / fault
 - Reduction of the grid's short circuit current

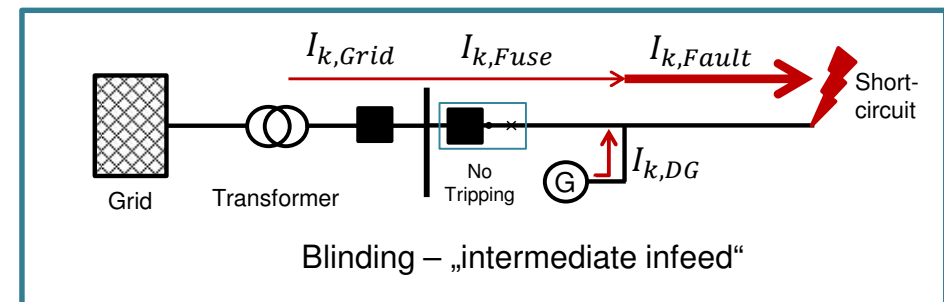


Blinding – „backward infeed“

➔ Increased fuse tripping time up to non-tripping

➔ **Blinding of protection**

- Through „backward infeed“
- Through „intermediate infeed“



Blinding – „intermediate infeed“

Smart Fuses for Smart Grids

Impact of distributed generation on low voltage grid protection

Blinding through “intermediate infeed”

- Laboratory test in the IFHT testing center

- Supply

- 400kVA, 10kV/0,4kV Dyn5 transformer

- Cable

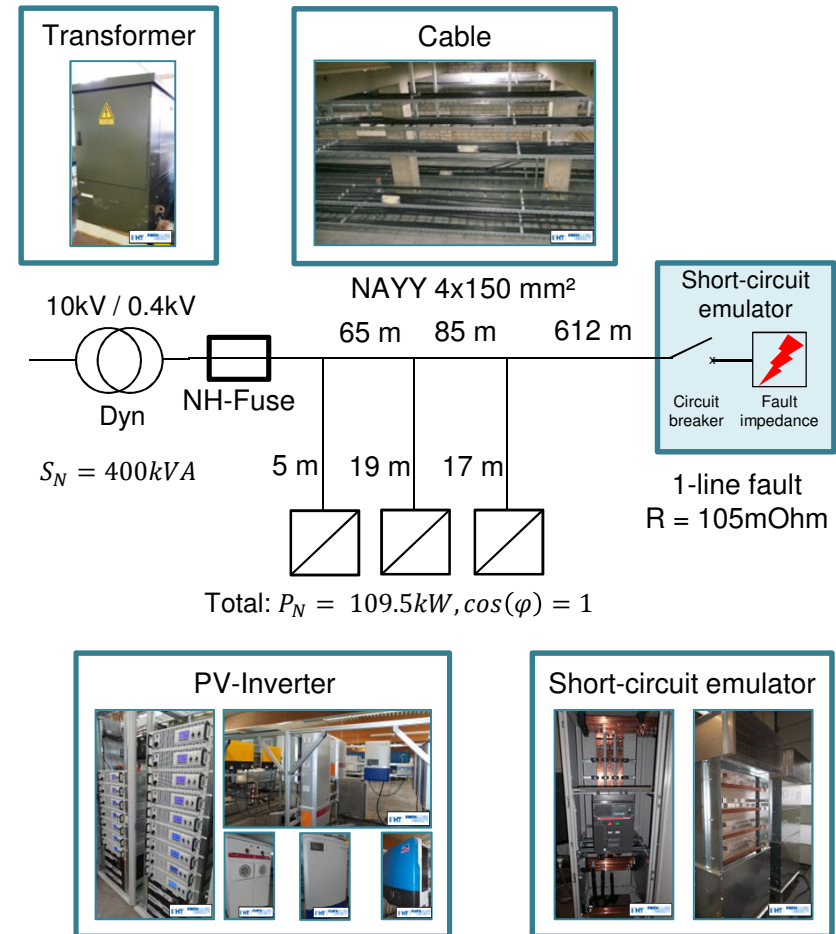
- 762m NAYY 4x150mm²

- Infeed

- Photovoltaik inverters ($P_N = 109,5kW$, $\cos(\varphi) = 1$, parametrization acc. to ARN4105)
 - Connected at 3 „residential service lines“ NAYY4x35mm², $L_{max} = 19m$

- Fault

- L1-Ground fault, $R_{Fault} = 105m\Omega$





Smart Fuses for Smart Grids

Impact of distributed generation on low voltage grid protection

Blinding through “intermediate infeed”

■ Laboratory test in the IFHT testing center

■ Short-Circuit experiments:

- 1. without PV-inverters 
- 2. with PV-inverters 

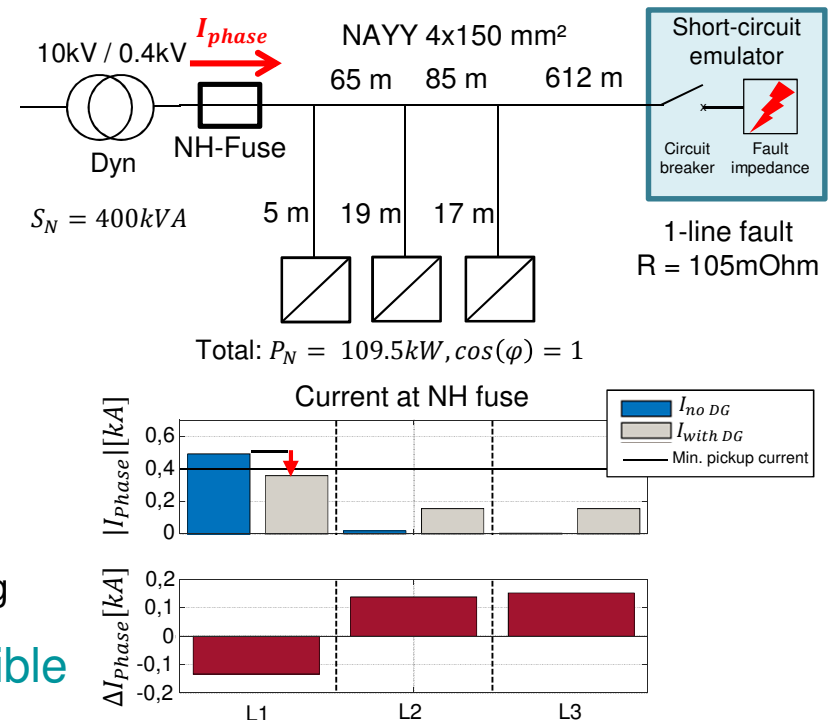
■ Evaluation:

- Fault-current at NH-Fuse (beginning of the line)
- 250A NH2 gG fuse
- Conventional fusing current: $1,6 \cdot I_N = 400A$

■ Results:

- $I_{phase,with DG} = 359A < 400A = 1,6 \cdot I_N$
- Fuse-tripping time increased up to a non-tripping

 **Blinding with PV-inverters in l.v. grids is possible**



Smart Fuses for Smart Grids

Definition of a smart fuse

- A smart fuse (or actor fuse) in this context means a fuse able to act on the command of a fault detecting device and to interrupt currents below its intrinsic time-current characteristic.
- Fault detecting devices may either be integral function of the fuse or external sophisticated grid control units as required for smart grids.

Smart Fuses for Smart Grids

Technical requirements for smart fuses

- Smart fuses shall be able to operate upon a signal of a fault detecting device.
- Smart fuses shall be able to interrupt fault currents below their minimum melting current.
- Smart fuses shall be able to interrupt over-currents faster than given by their intrinsic time-current characteristic.
- Smart fuses shall provide selectivity of protection beyond standard selectivity rules.
- Smart fuses shall operate according to their intrinsic characteristic unless triggered by an external signal.

Smart Fuses for Smart Grids

Expected features of smart fuses

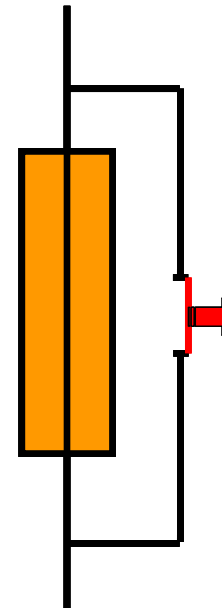
- Smart fuses interrupt fault currents equal to or below normal operating currents.
- Smart fuses overcome blinding problems in l.v. distribution grids.
- Smart fuses reduce hazards of impedance limited arc flash (see presentation H. Schau).
- Smart fuses are able to interrupt longitudinal arcs and thus to reduce the risk of fire.
- Smart fuses provide fail-safe overcurrent protection.
- Smart fuses fit existing fuse-bases in l.v. distribution systems.

Smart Fuses for Smart Grids

Potential solutions

Bypass solution

- Well known for m.v. applications
- Difficult to realize for l.v. circuits
- No fail-safe protection

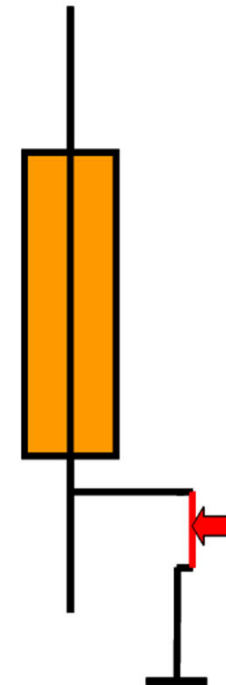


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Potential solutions

Solid grounding

- Common solution for arc fault energy limitation
- Limited selectivity of protection
- Fail-safe circuit protection

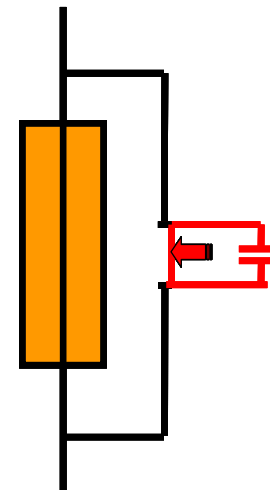


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Potential solutions

Electric pulse added

- Opening of restrictions by high I^2t injection
- Limited by surge voltage level
- Fail-safe circuit protection

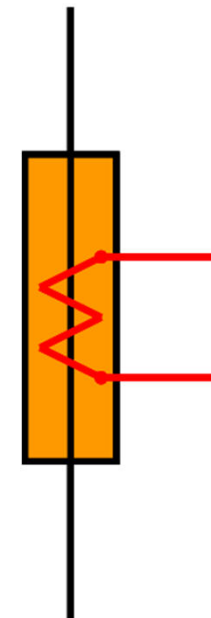


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Potential solutions

Heat pulse added

- Additional electric heat supports M-effect
- Reactive substance boosts temperature-rise
- T/C characteristic is shifted to the left by external heat injection
- Fail-safe circuit protection

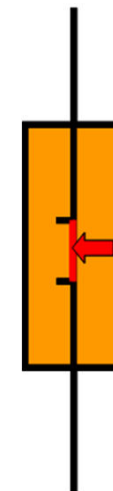


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Potential solutions

Mechanical break

- Realized on h.v. fuse-links
- Mechanical break in fuse-elements interrupts low fault currents
- Fail-safe circuit protection



Conclusions

- Distributed generation in l.v. grids is challenging traditional system protection.
- Smart fuses will be able to cope with future requirements for l.v. grid protection.
- Smart fuses offer more safety features than just overcurrent protection.
- Fuse technology may be at the rim of a new fuse generation!

Schutzsysteme für die Verteilungsnetze der Zukunft Protection for Future Distribution Systems



Thank you for your attention

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