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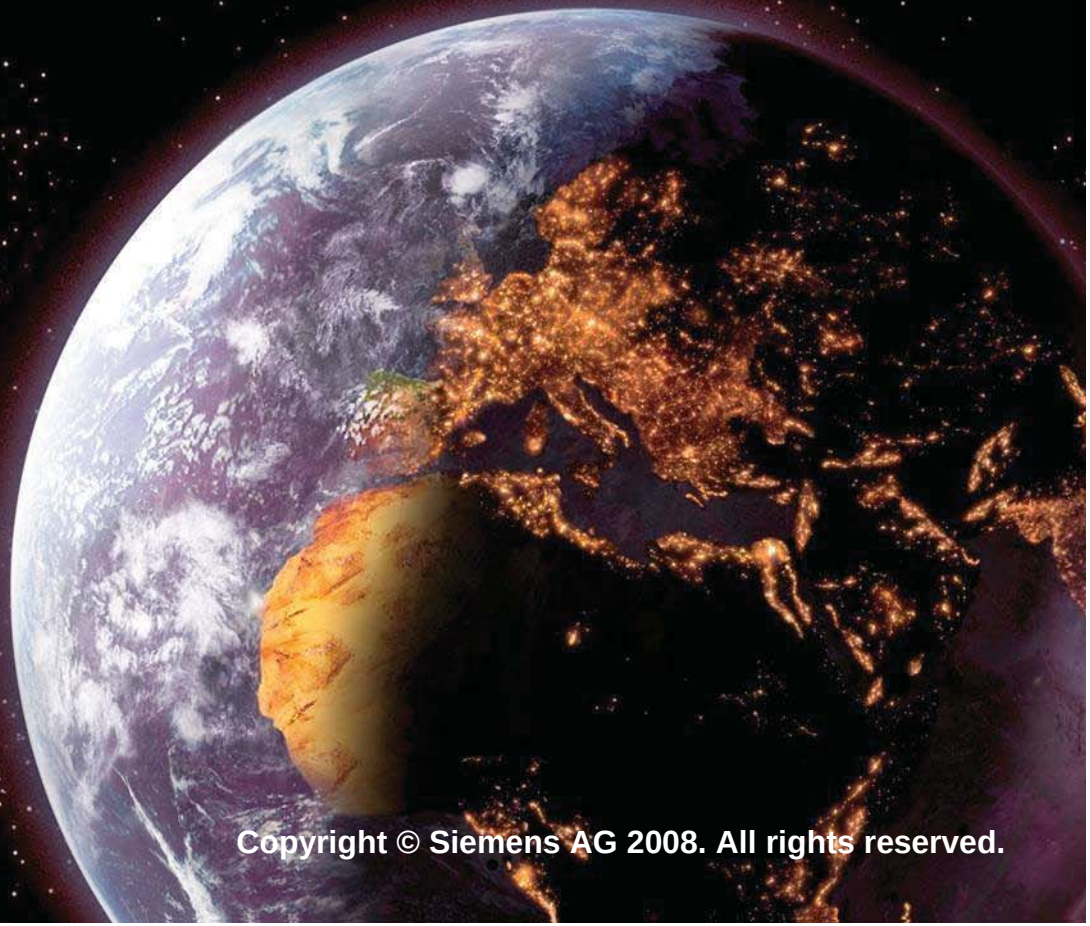
Practical Examples

Sector Energy PTI NC

Theodor Connor



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Content

Industrial network

Coal mine supply network

Rural supply network

Performance of Industrial Network improved by Low Resistance Neutral Treatment

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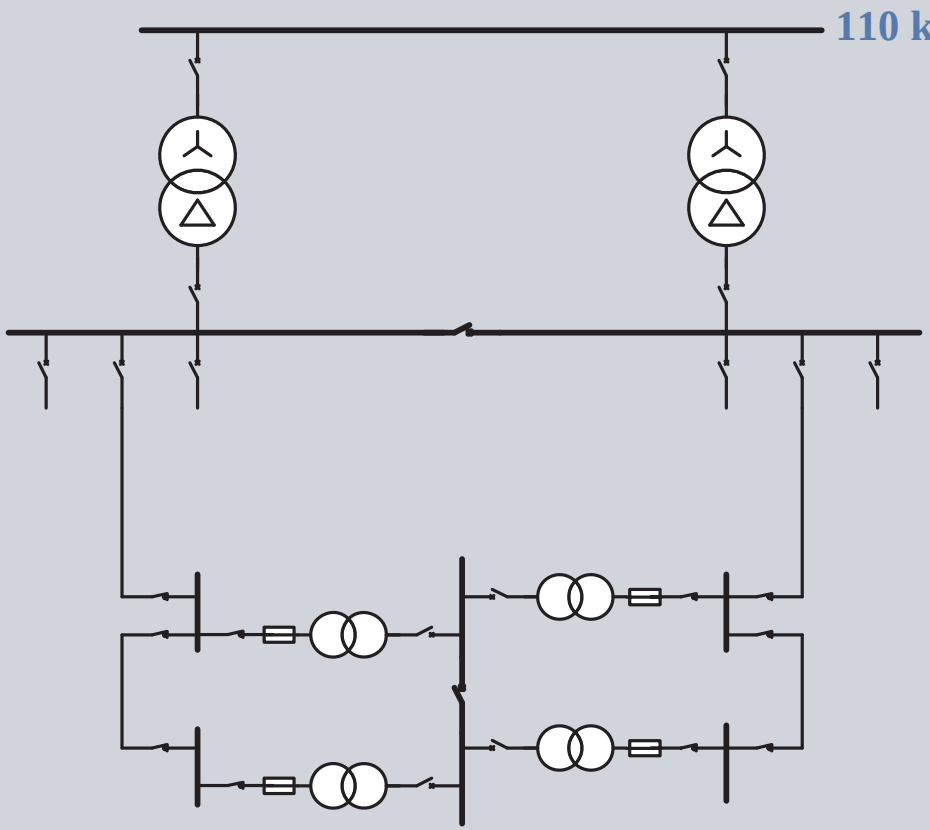
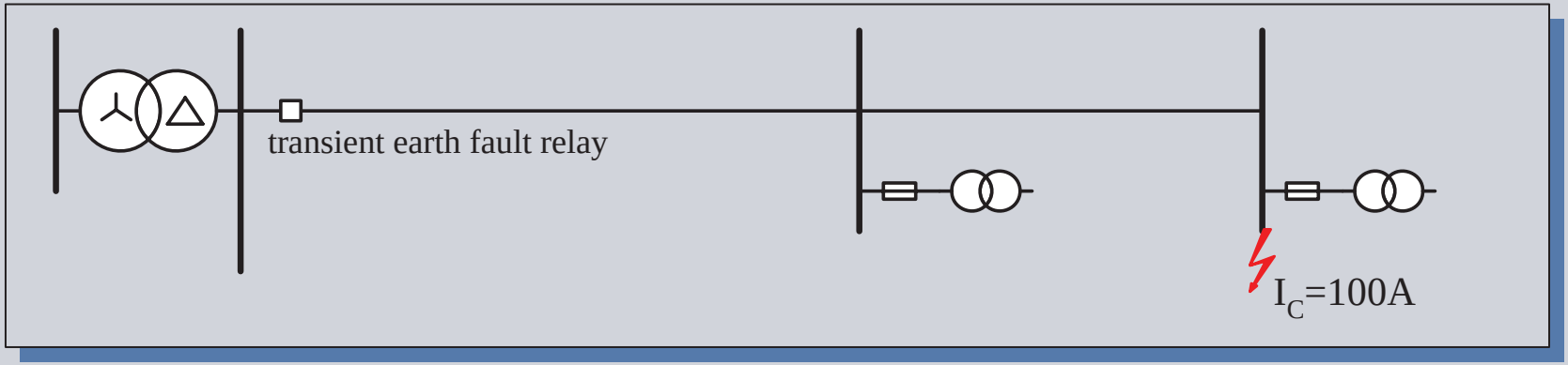


6 kV switchgear
(with circuit breakers)

0.4 kV
busbar

6 kV unit substation
(with load interrupter switches and HV fuses)

Initial state (isolated neutral)



unreliable operation of transient earth fault relays
high overvoltages (transient and power frequent)
high fault current over a long time
→ virtually every earth fault results in multi-pole fault
high voltage dips in 0.4 kV system in case of multi-pole 6 kV fault
man power needed for fault location and switch off

Steps of Investigation

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Measurements for data acquisition

- Zero sequence impedance; Reduction factor of cable shield
- Earthing and touch Voltages

Calculation of earth fault currents

Comparison of variants of neutral treatment

- Effects on operation; Risk of fault propagation
- Devices for fault detection and protection
- Neutral devices
- Compliance with touch voltage criteria

Installation of proposed variant of neutral treatment

Commissioning and earth fault test

Measurements for data acquisition

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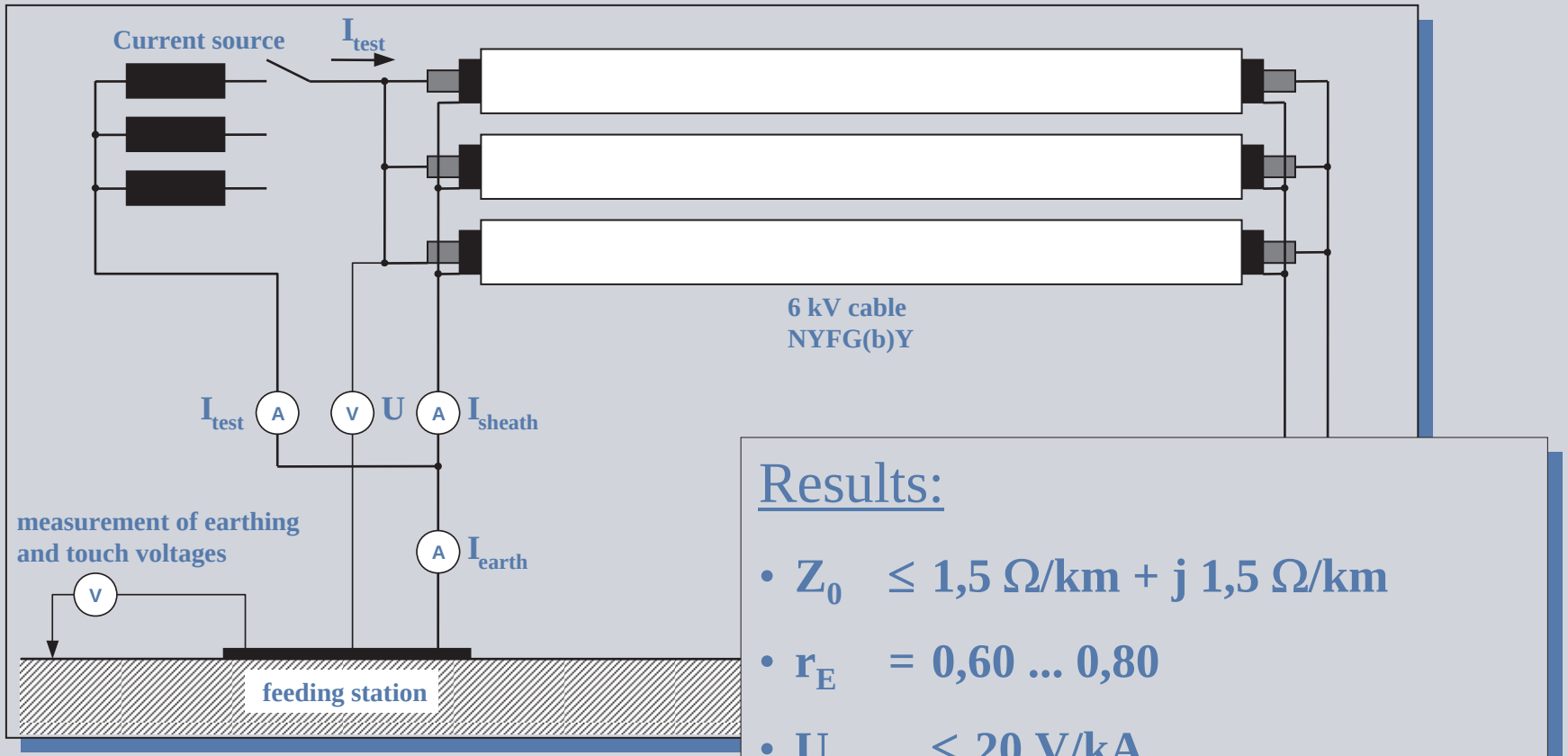
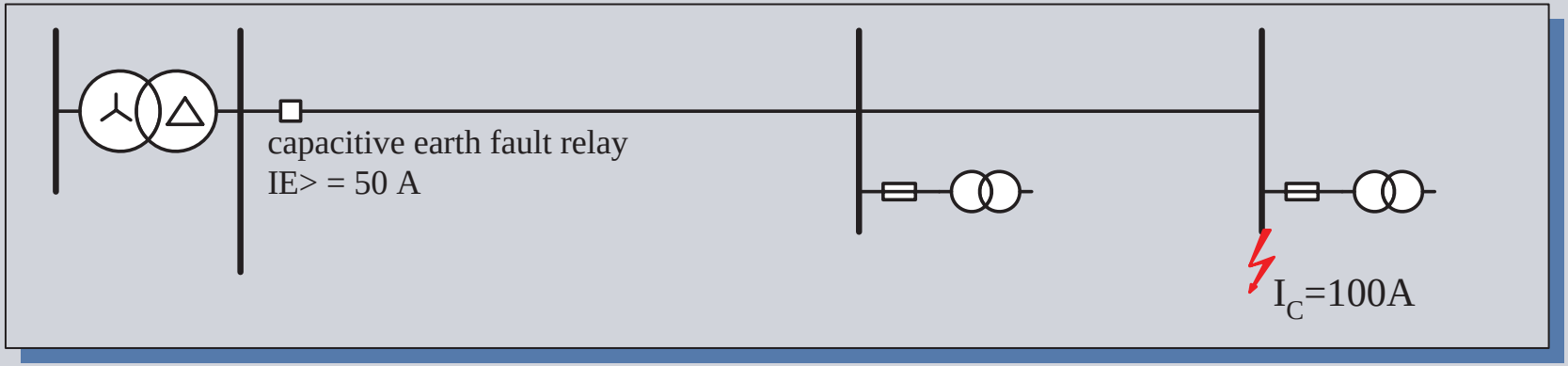


Results:

- Z_0 ≤ 1,5 Ω/km + j 1,5 Ω/km
- r_E = 0,60 ... 0,80
- U_E ≤ 20 V/kA
- U_B ≤ 10 V/kA

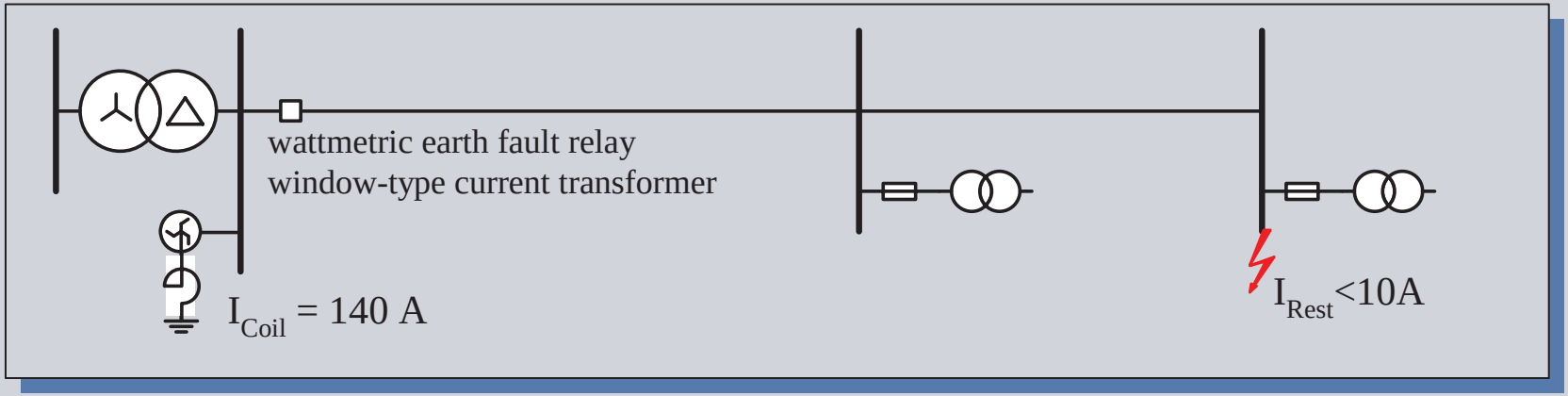
Improved operation with isolated neutral



no interruption of supply
no cost for neutral devices

high fault current over a long time → risk of multi-pole fault
high overvoltages (transient and power frequent) → risk of double fault
new capacitive directional earth fault relays necessary
man power needed for fault location and switch off

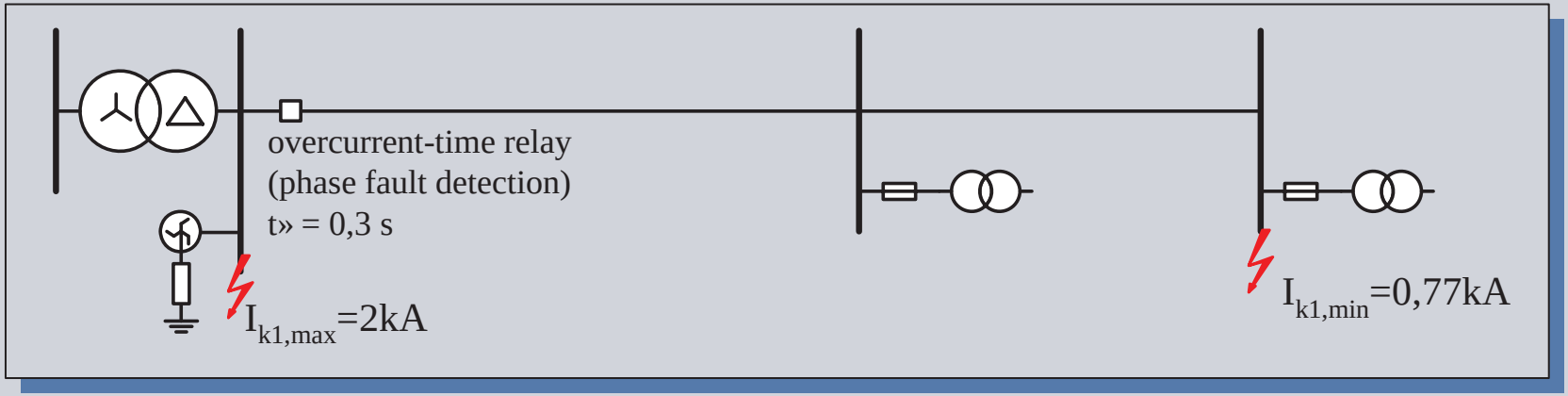
Operation with earth fault compensation



no interruption of supply
small earth fault current → low risk of multi-pole fault

high overvoltages (transient and power frequent) → risk of double fault
new wattmetric earth fault relays and window-type transformers necessary
high costs for neutral earthing transformer and arc suppression coil
man power needed for fault location and switch off

Low impedance earthing 2000 A



fast fault clearing → low risk of multi-pole fault

no transient overvoltages → low risk of double fault

existing overcurrent-time relays with phase fault detection can be used

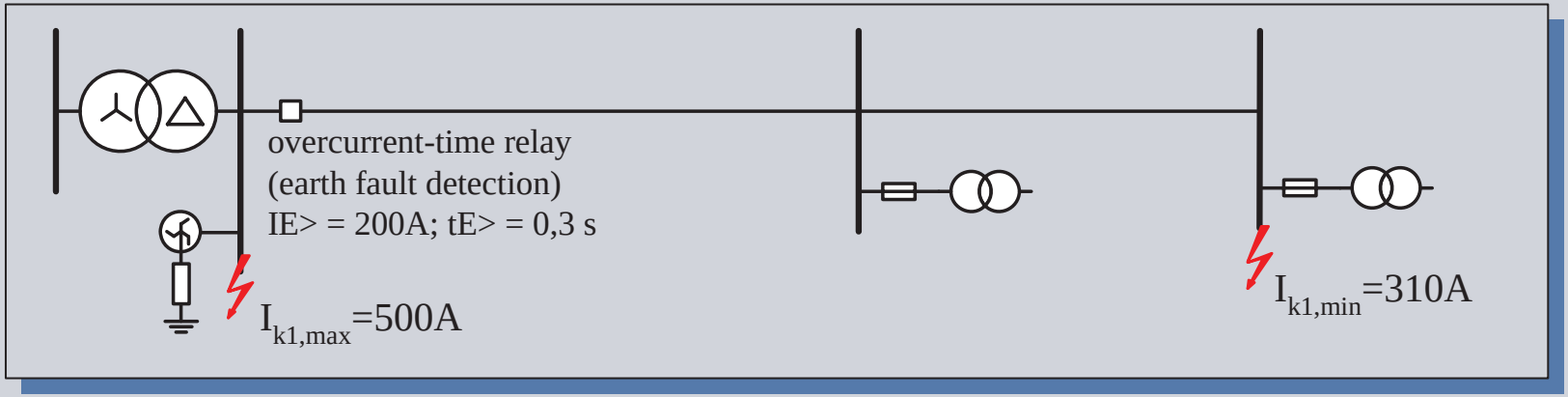
setting of phase fault detection must changed to

- smaller starting currents (to detect earth faults) and
- higher delay times (to prevent tripping by inrush currents)

voltage dips of up to 10 % in 0.4 kV system in case of 6 kV earth faults

unselective or no tripping of HV fuses

Low impedance earthing 500 A



fast fault clearing and low fault current → low risk of multi-pole fault

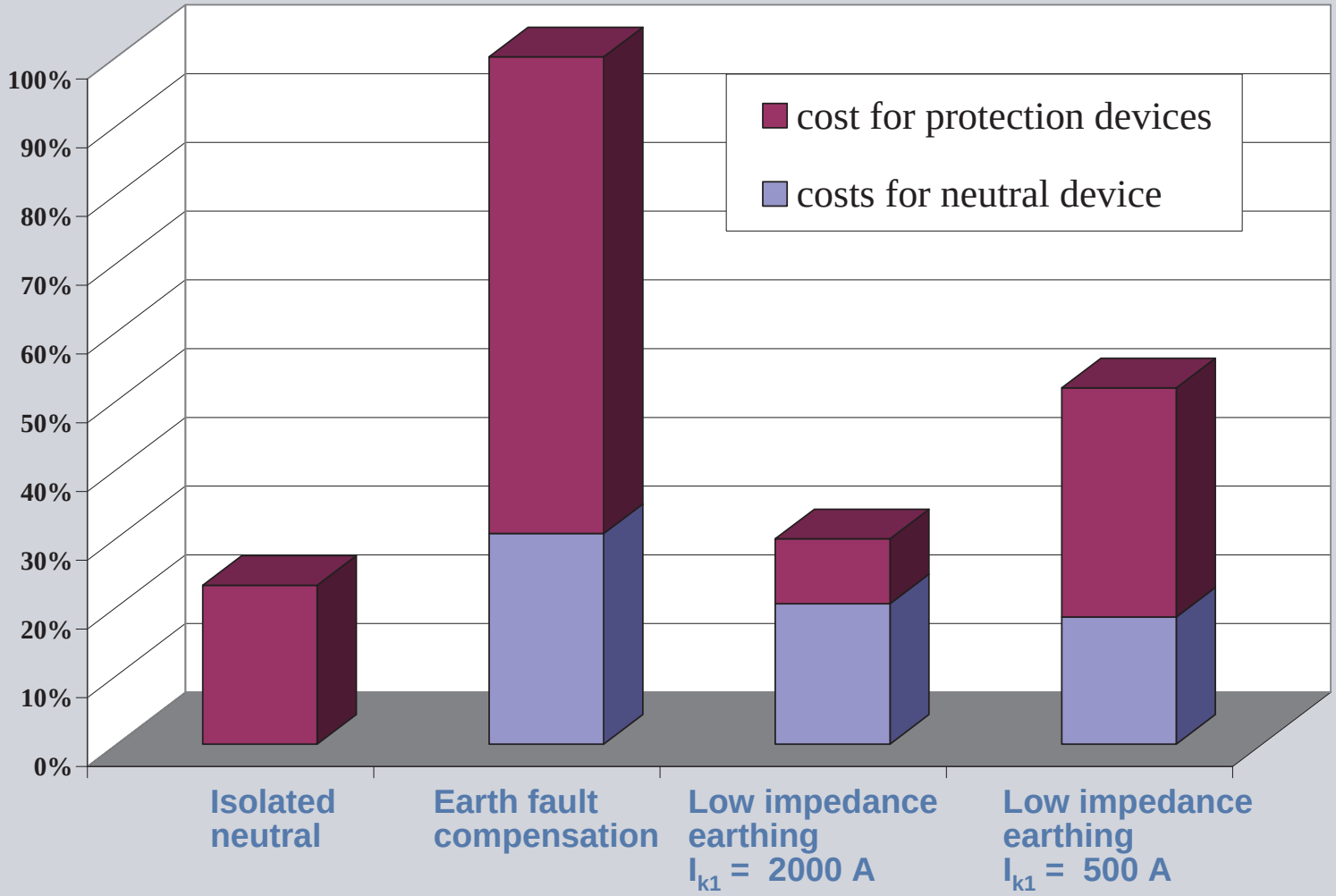
no transient overvoltages → low risk of double fault

low voltage dips in 0.4 kV system in case of 6 kV earth faults

new overcurrent-time relays with earth fault detection necessary

unselective or no tripping of HV fuses

Comparison of Investment Costs



Equipment used for low impedance earthing

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Neutral earthing transformer

Neutral resistor

Results of the short-circuit test

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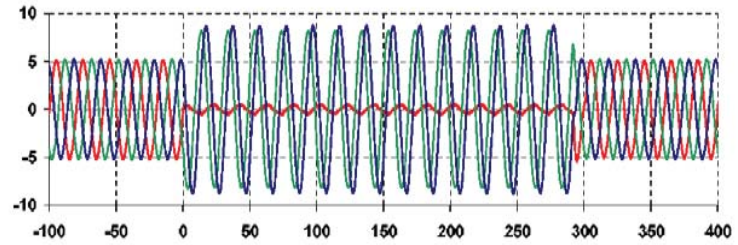
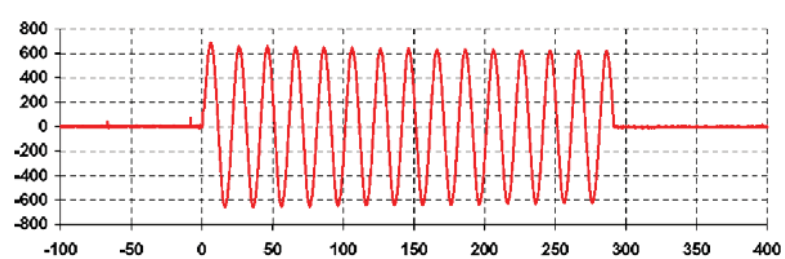
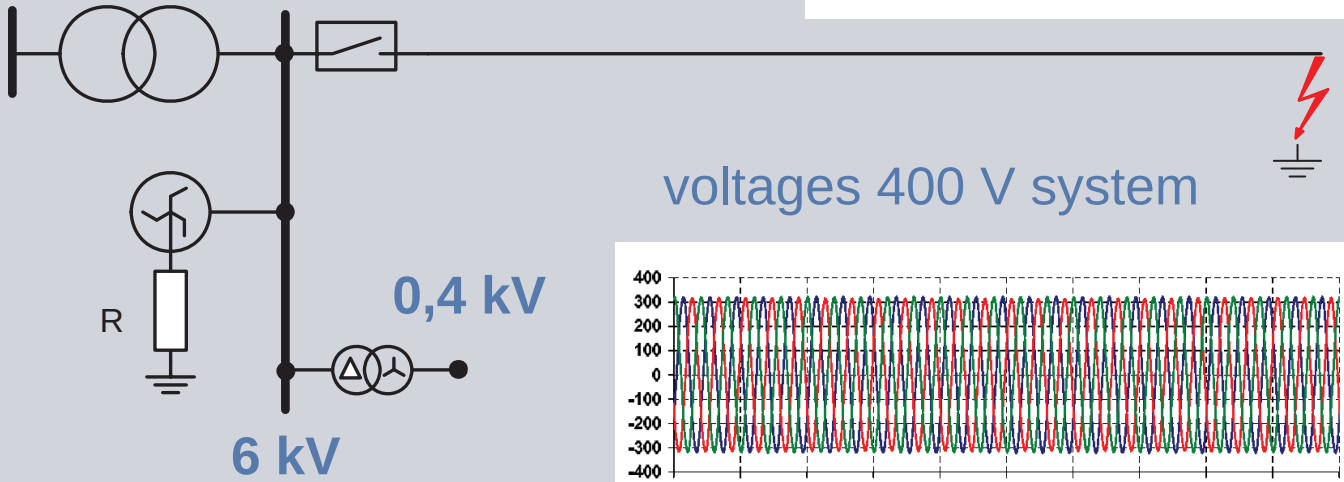
voltages 6 kV system



earth fault current





voltages 400 V system

Operational experience

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low impedance earthing (Ik1 = 500 A) is in operation for more than 2 years

2 earth fault were selectively cleared by protection relays

no unselective tripping in response to earth fault starting

no sensible voltage dips in 0.4 kV system during 6 kV earth faults

Adequate neutral treatment for 25kV power supply systems of a new huge open cast lignite mine

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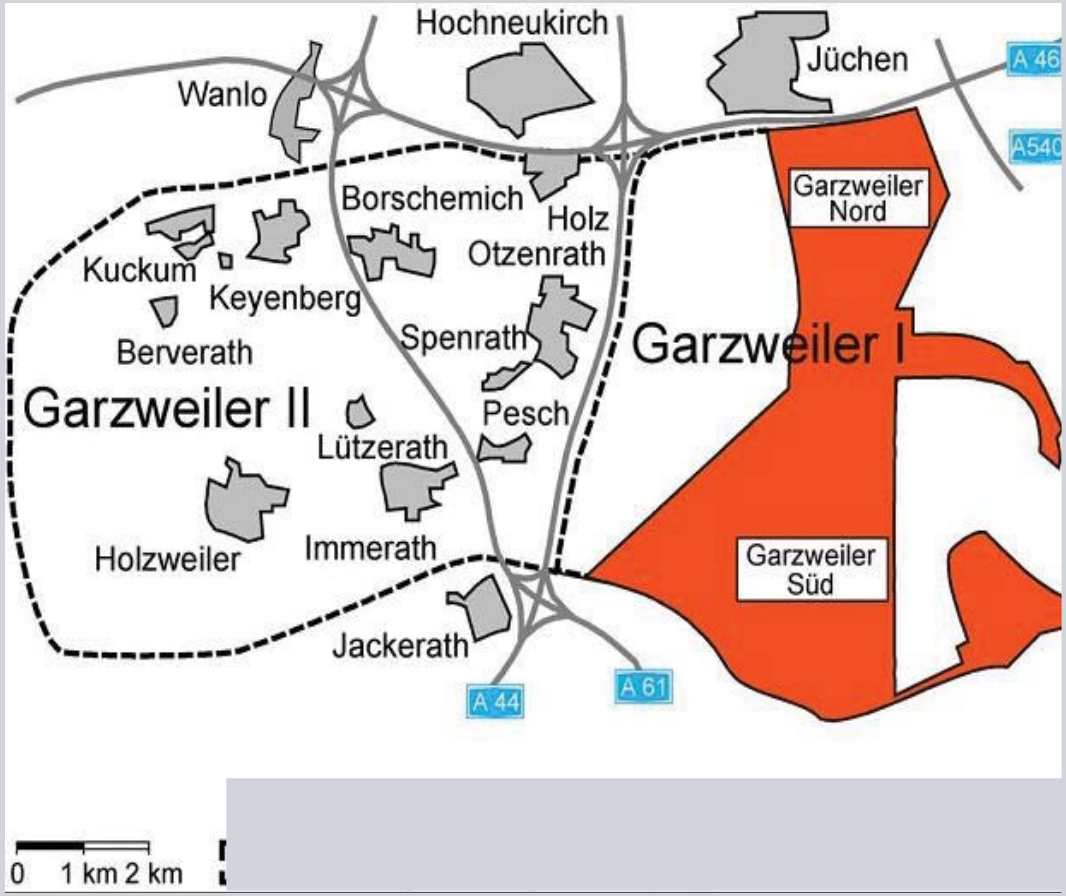

Open cast mine typical equipment

Charakteristics of power supply of open cast lignite mine

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- Movement of equipment like stations, transformers, conveyer belts and excavators´ following the work progress
- Heavy duty conditions due to large mechanical stress, dust, rock, rain, heavy vehicles
- Movement of ground due to soil instability in excavation or fill up areas
- Not all areas are accessible at all time due to work progress
- Reliability requirements regarding permanent output of coal mines due to nearby power stations and maintaining ground water level
- Fault detection selectivity and speed of fault clearing due to reliability requirements

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Power supply system of Garzweiler II

- Nine 110kV bays, single bus bar, located at 110/25kV main substation Jackerath
- Six 110/25kV transformers with together 390 MVA, located at 110/25kV substation Jackerath
- Eighty 25kV bays, double bus bar, located in the main substation Jackerath
- 165 km of 25kV lines and cables feeding 45 medium voltage transformers (25/6kV) with together 438MVA.
- The network is operated as radial system equipped with over current protection

Parameters for Comparison

Voltage dependent aspects

- Transient over voltages
- Power frequency over voltages

Current dependent aspects

- Damages at fault location
- Touch Voltage
- Inductive interference
- Thermal stress of equipment

Operational

- Fault detection
- Fault location
- Amount of switching for re-supply required
- Possibility for automation of operation

Investment

- Cost for neutral treatment equipment
- Cost for protection

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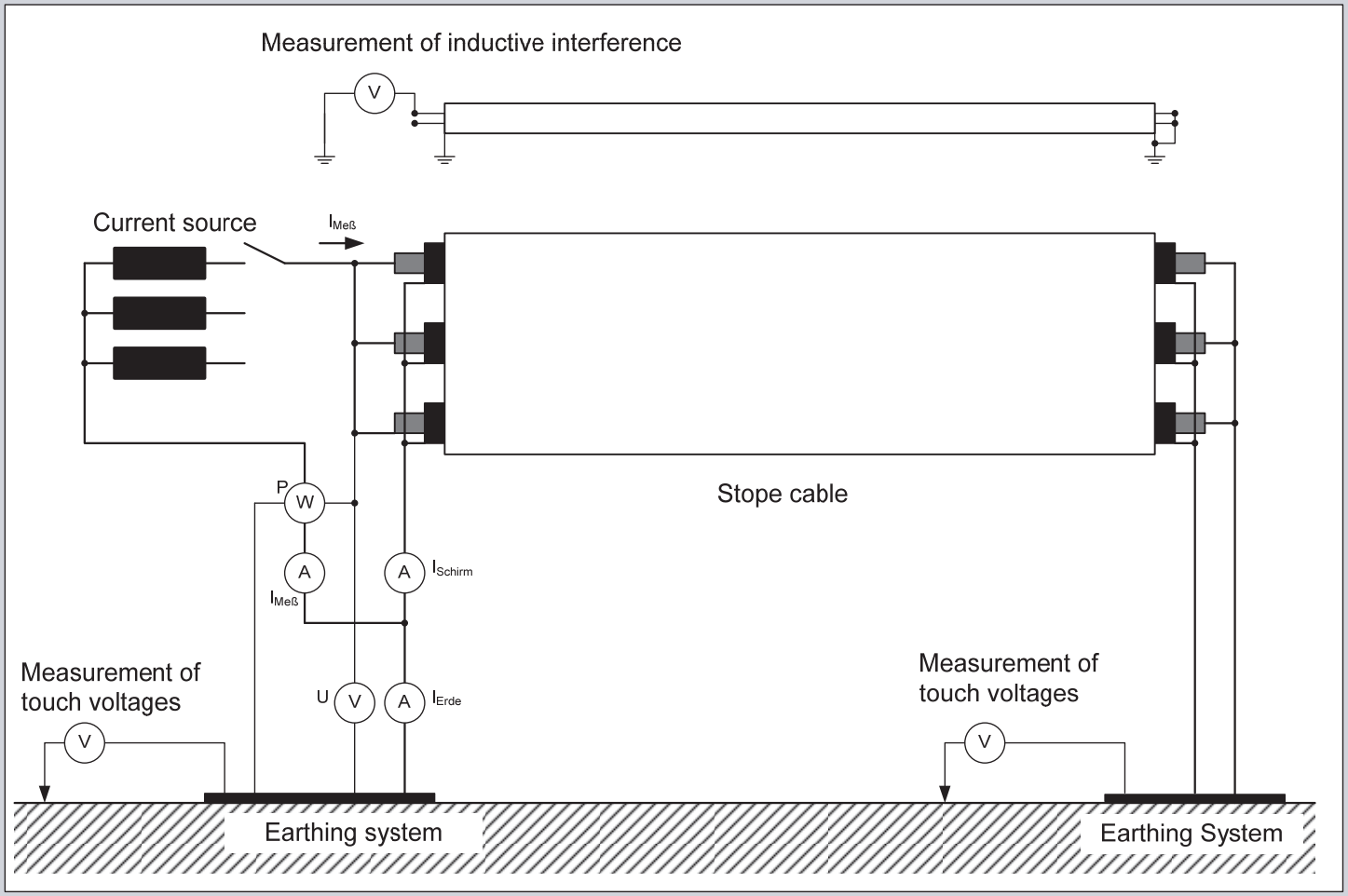
Measurements for data collection



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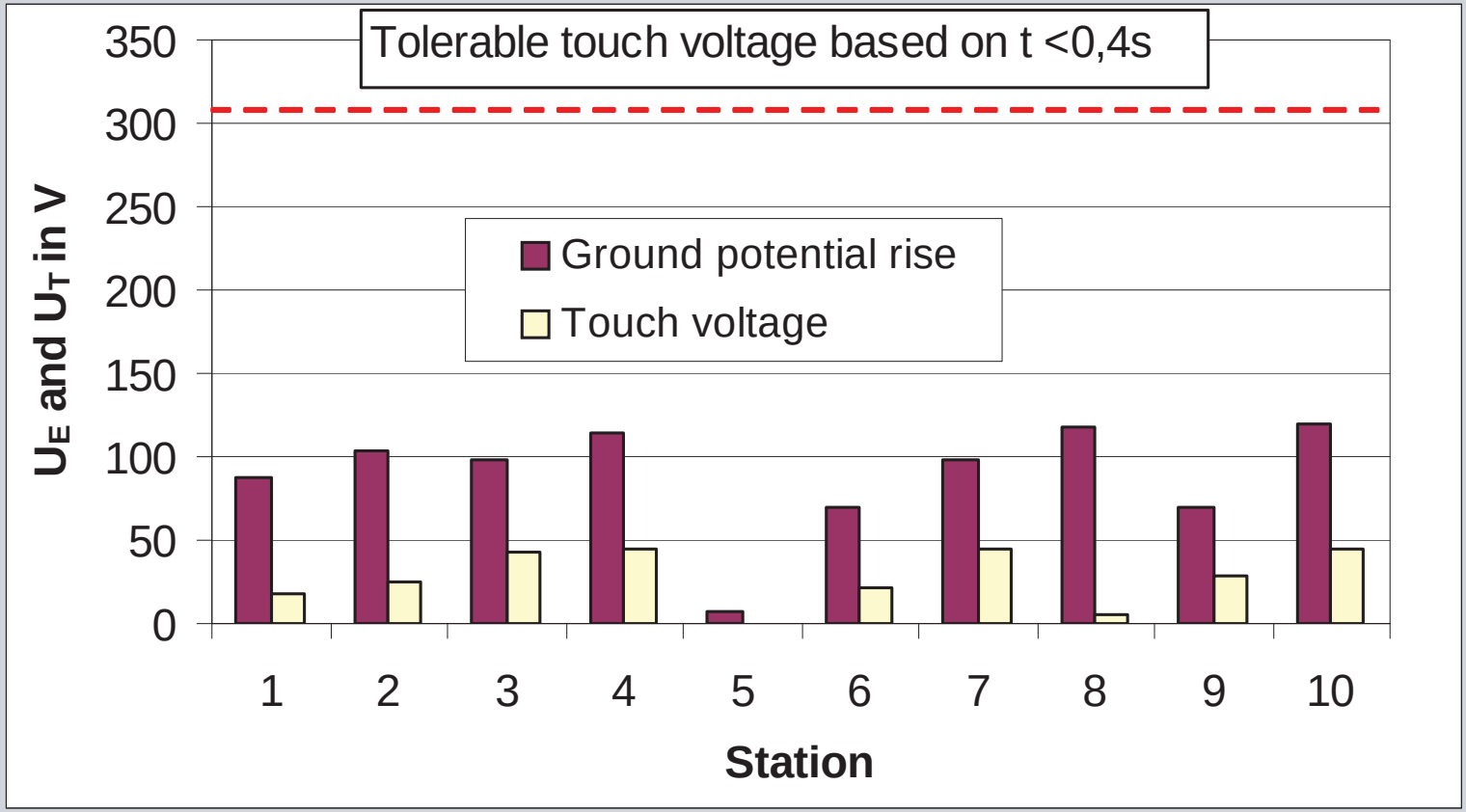
Results of Heavy Current Injection Tests



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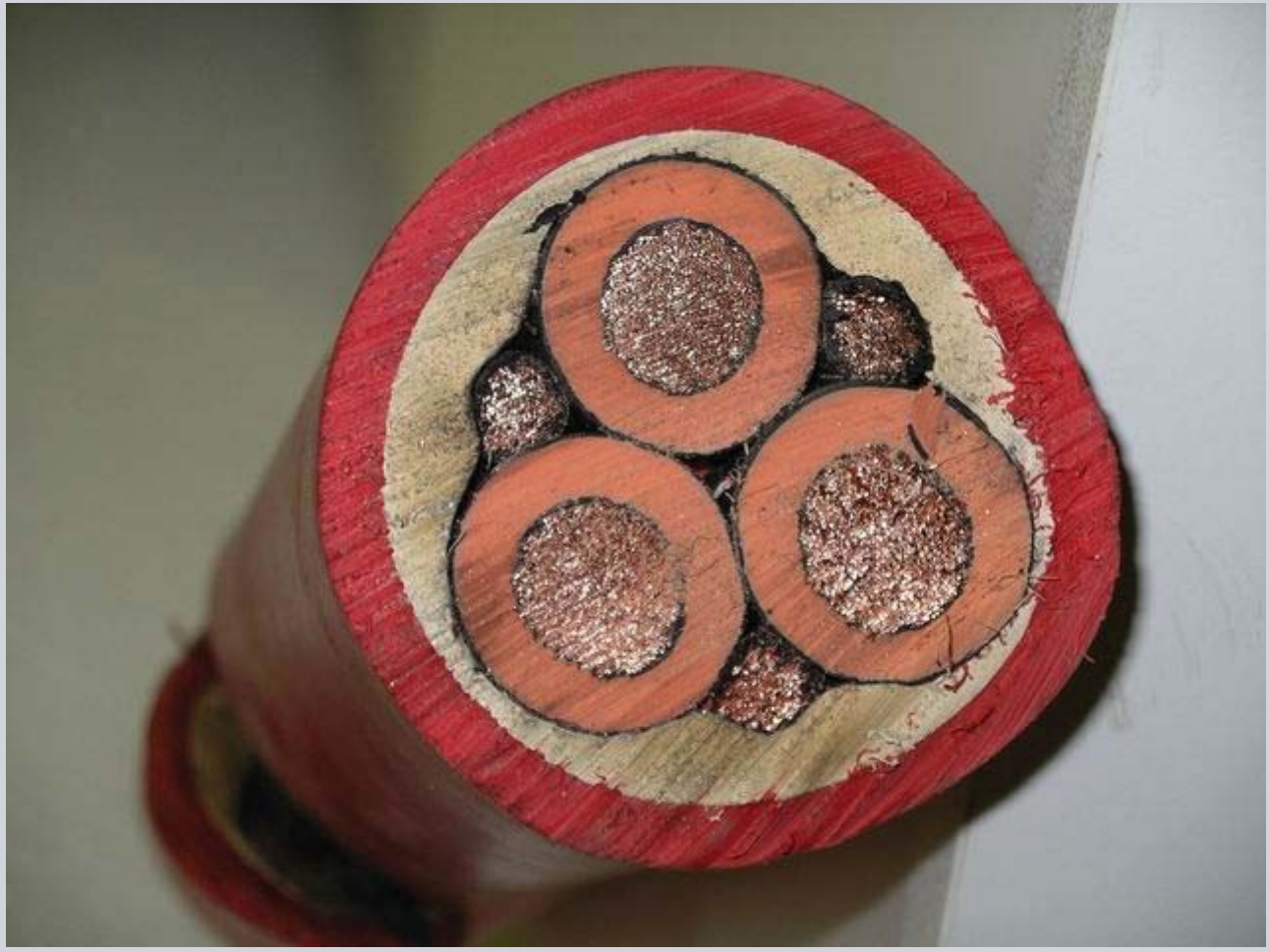
Construction of a Stope Cable



Earth fault trails in the new 25kV system

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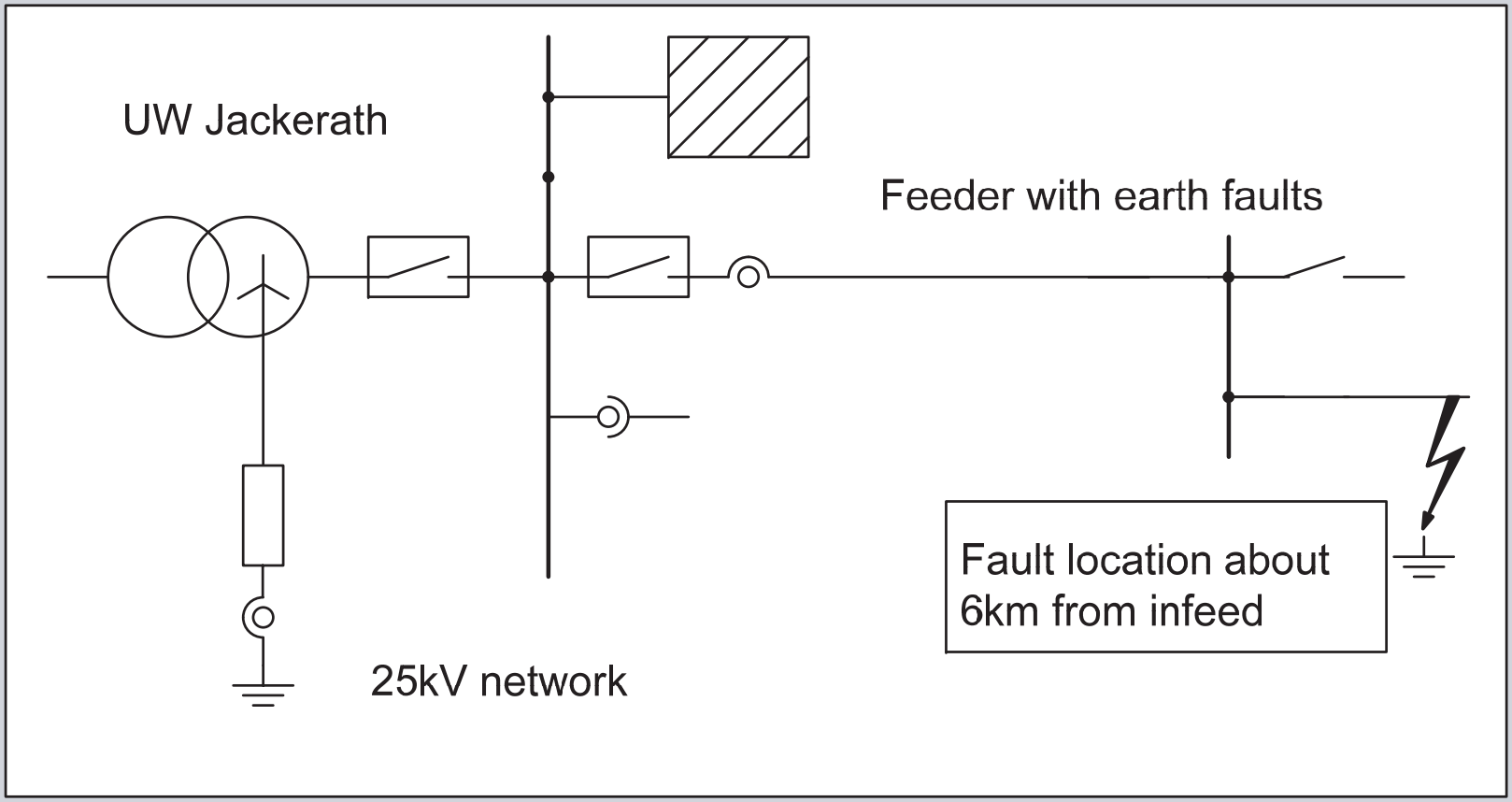

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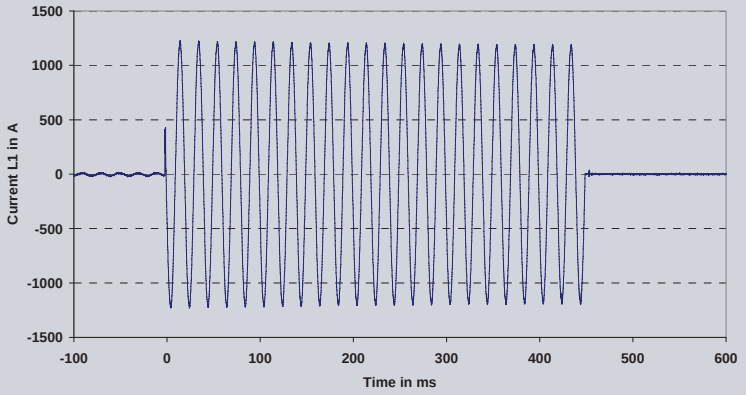
Preparation of Test Stope Cable

Current of faulted phase:



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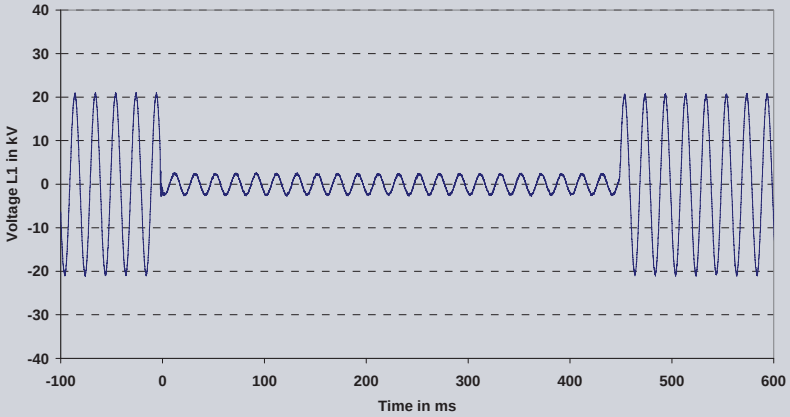
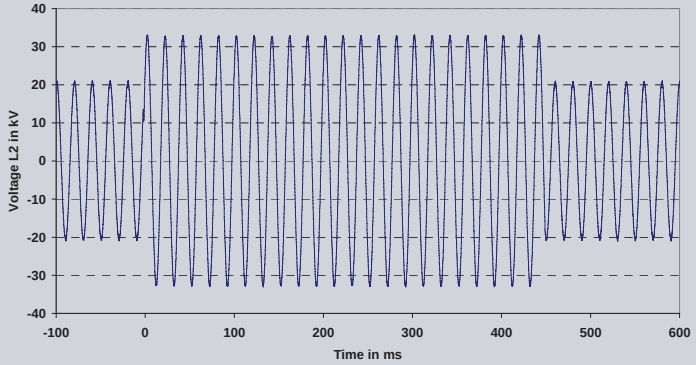
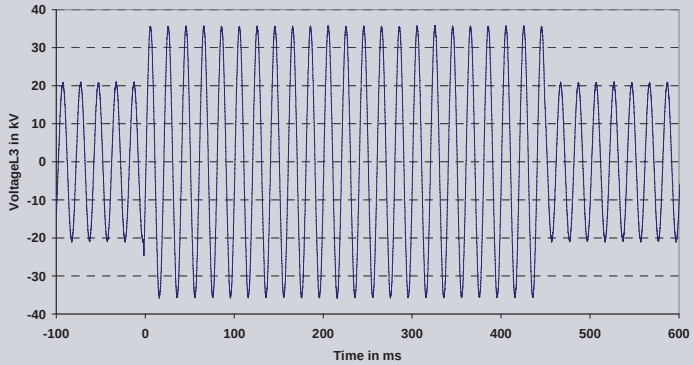
Readings of voltages during test

Voltage of faulted phase



Voltages of unfaulted phases





Advantages of proposed current limiting neutral earthing

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- The risk of earth fault developing into cross-country faults is eliminated
- Fast and selective tripping of faulty feeder by protection devices
- Fast fault location
- Possibility of automation of network operation is given
- Lowest Costs

And it happens!

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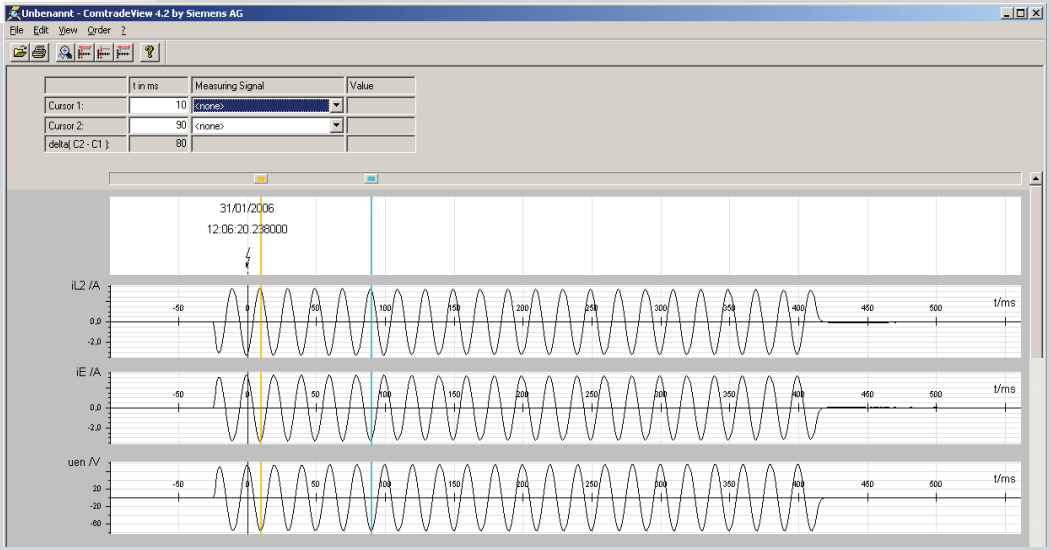

EARTH FAULT TRAILS AND MEASUREMENTS IN RURAL 20 kV NETWORKS

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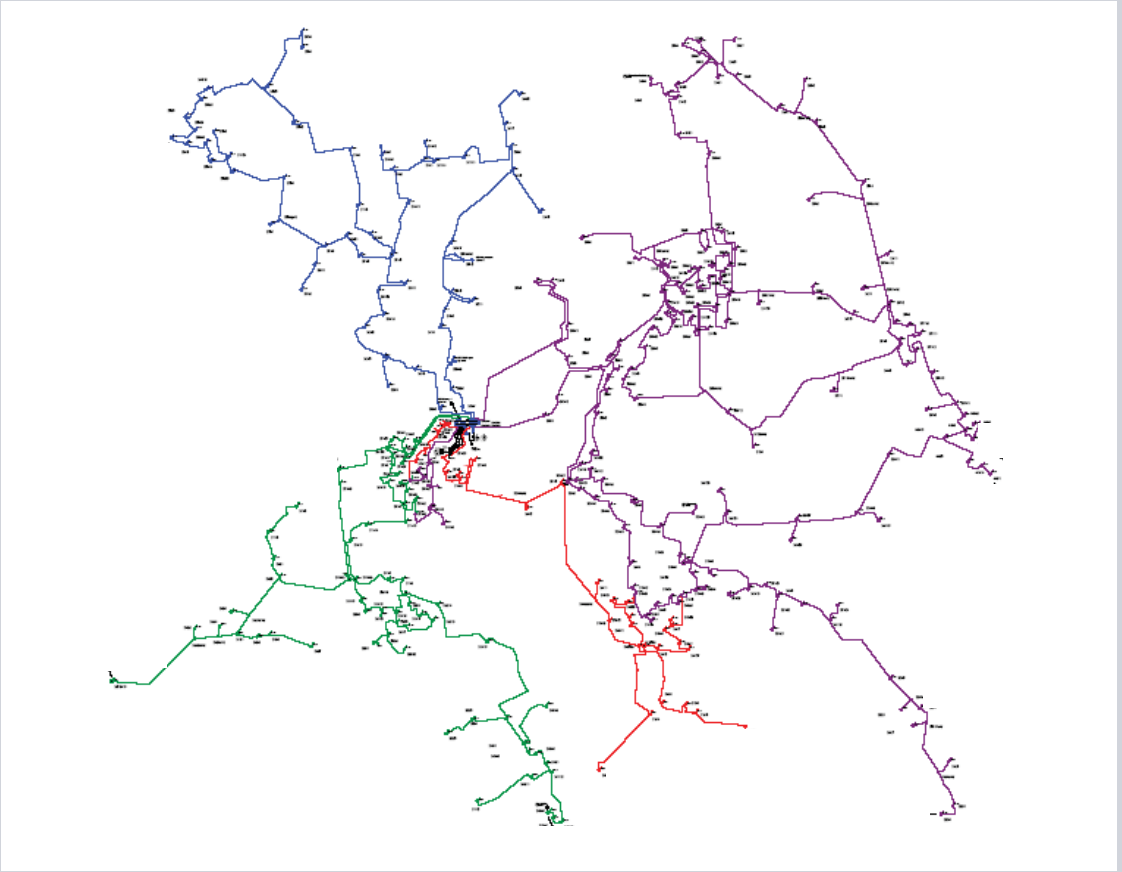
Investigated 20kV network



Results of earth fault trials

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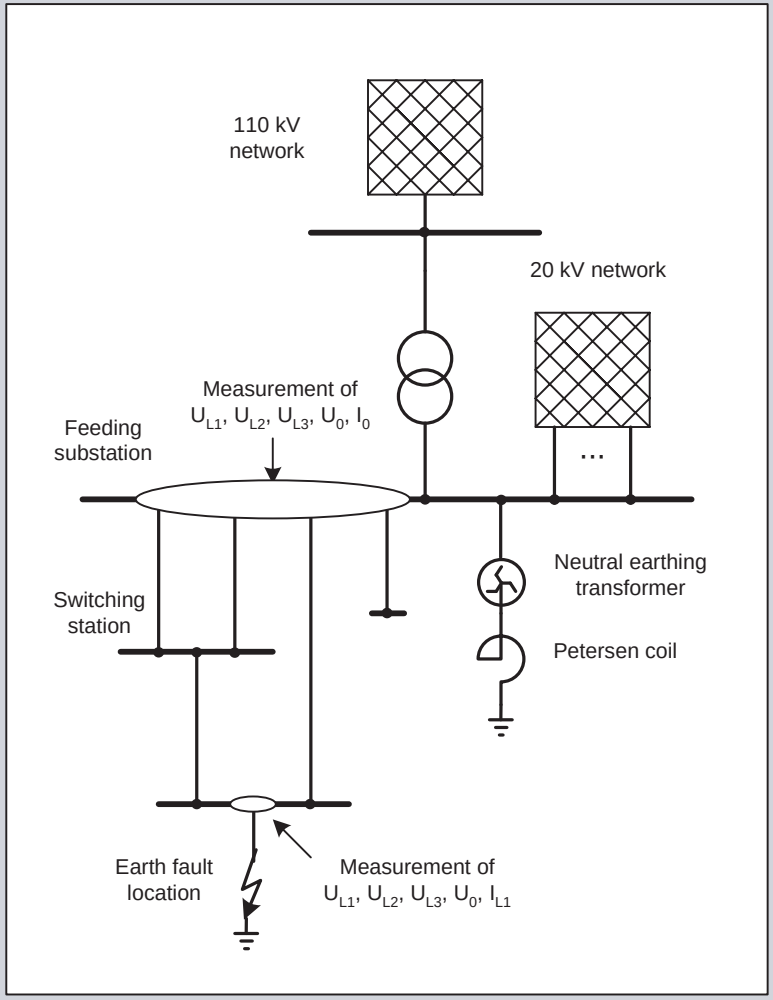
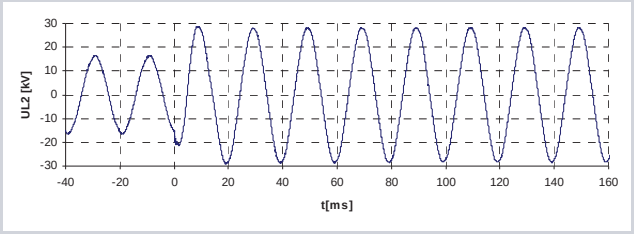
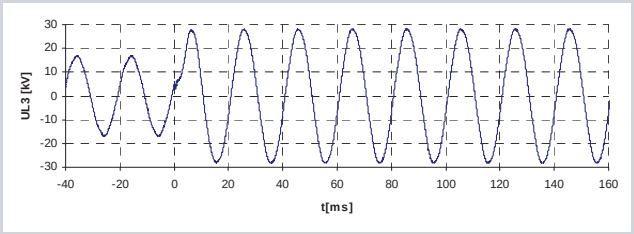
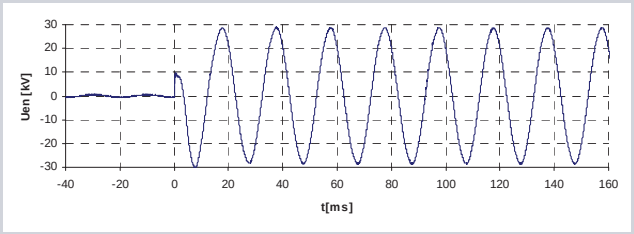
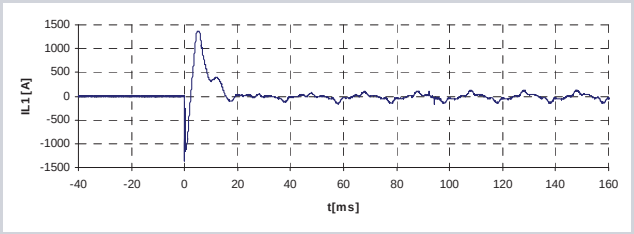


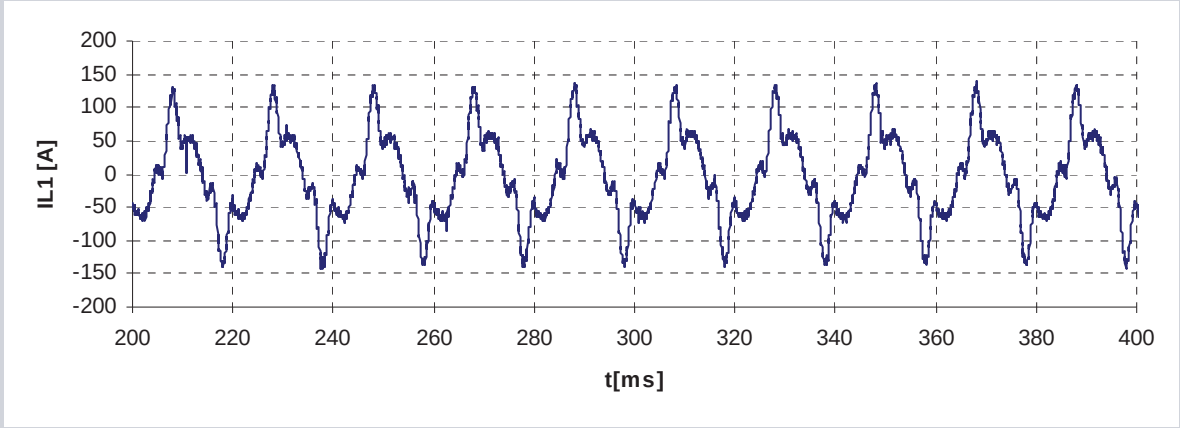


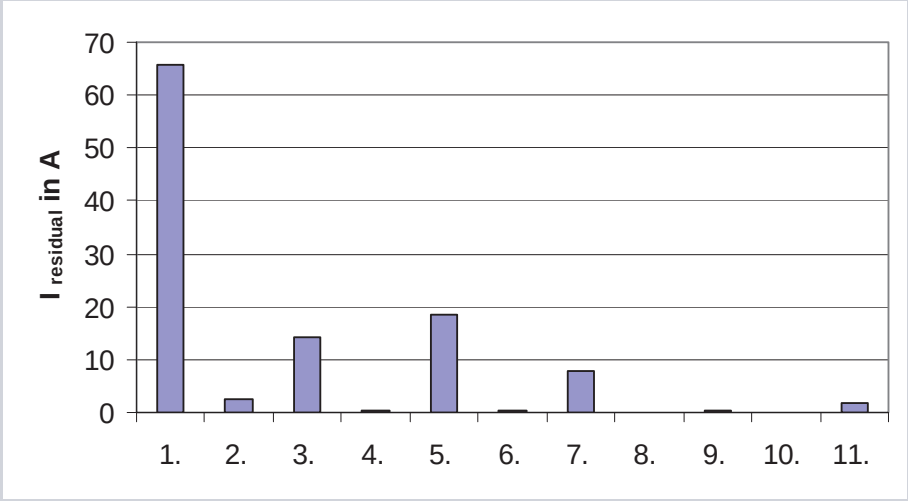




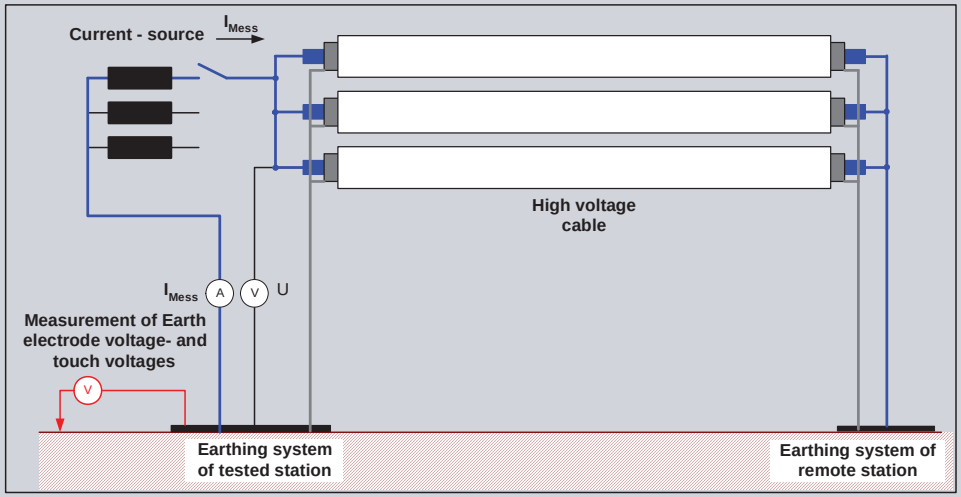


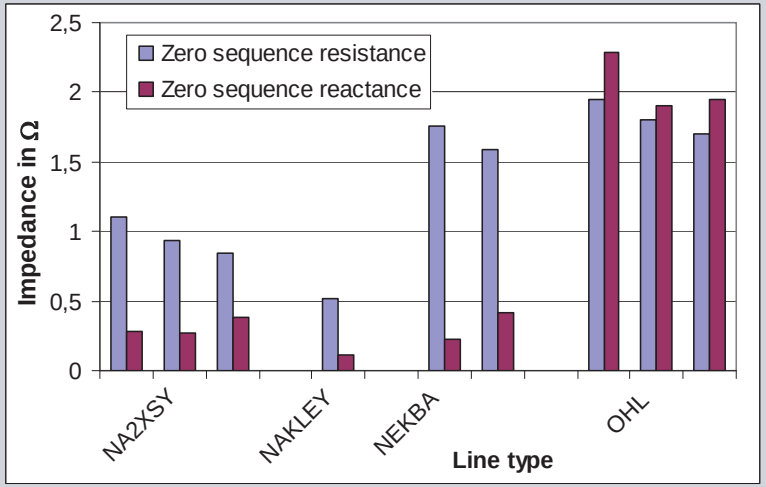
Harmonic analysis of residual current

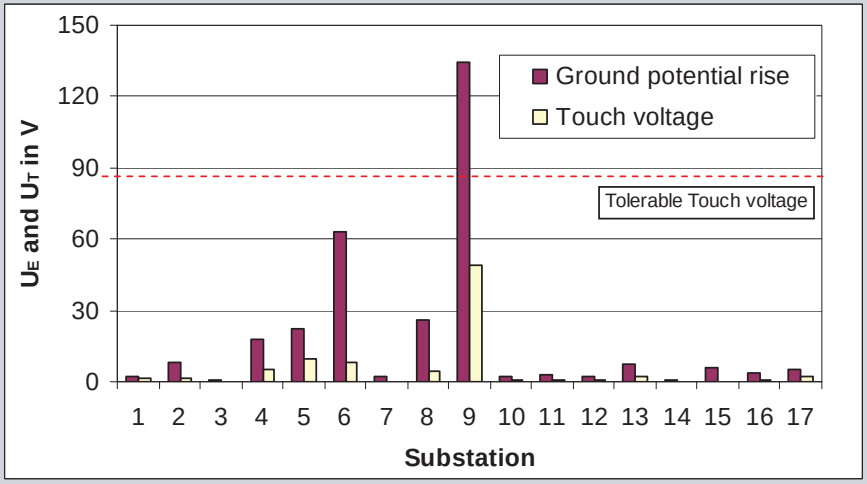




Results of heavy current injection test







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Comparison of variants of neutral treatment