Communication gives reliable protection or a contradiction?

COMMUNICATION BASED PROTECTION

2 JUNE 2022

TU Delft PPC

STEDIN.NET | VOOR DE NIEUWE ENERGIEGENERATIE

ABOUT STEDIN

Stedin is a grid operator in most of the Randstad, including The Hague, Utrecht, Rotterdam and the Rijnmond port and Botlek area.
It is an urban area with complex infrastructure, where energy dependence is high.
We also manage the gas infrastructure in the regions of Kennemerland, Amstelland and Northeast.

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CONTENT

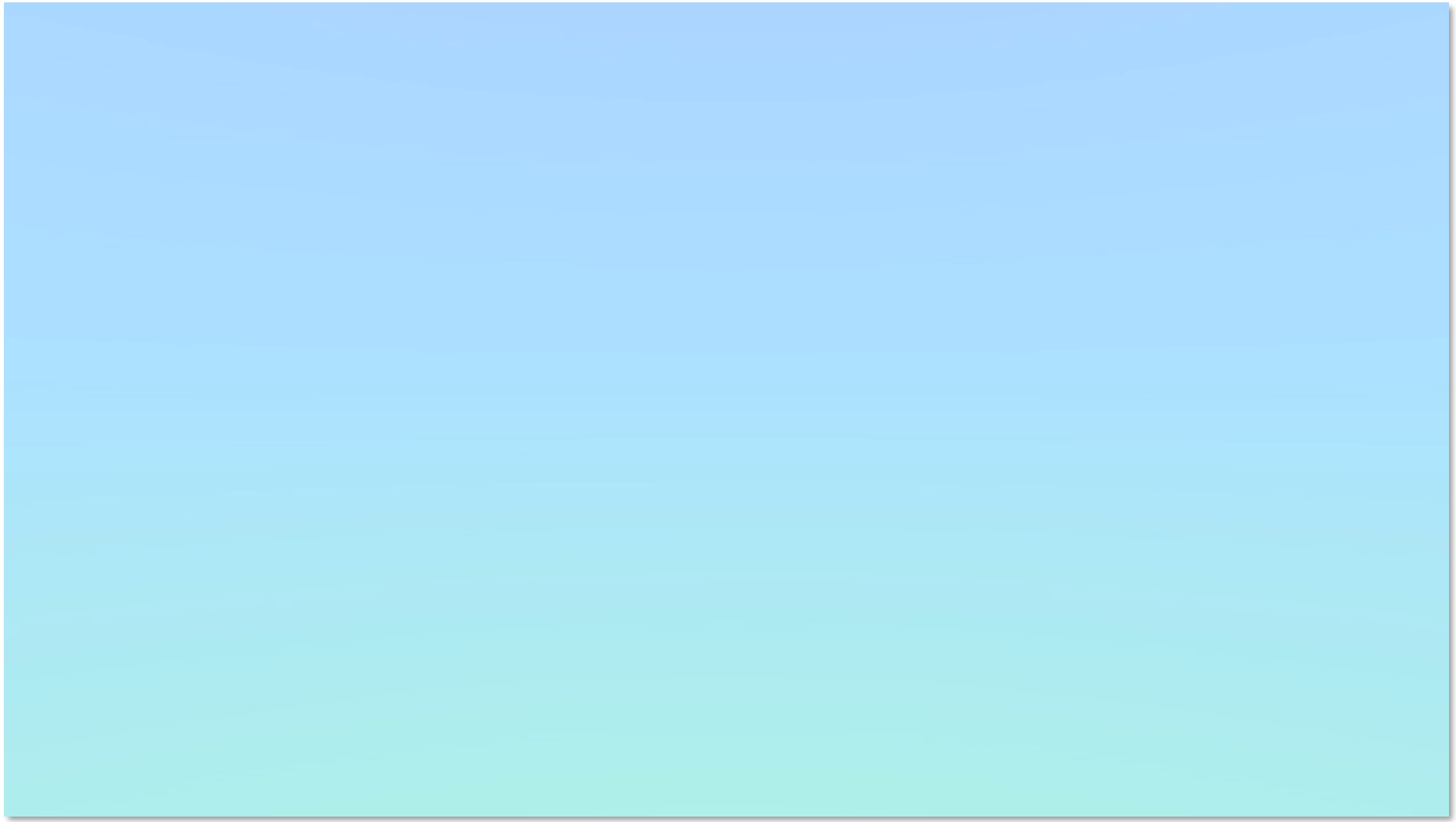
- Communication vs reliability
- Considerations
- Protection system
- Communication based protection
- Examples
  - Adaptive protection
  - Semi Busbar Protection, one phase fault detection (Stedin, TU Delft)
  - Future cable protection system (Stedin, TU Delft)
  - Maintenance
  - WAMPAC (this afternoon by GE)
- What if communication fails?
- Conclusion

CONTRADICTION

COMMUNICATION BASED PROTECTION RELIABLE?

tvtropes.org

TRANSITION ORGANIZATION

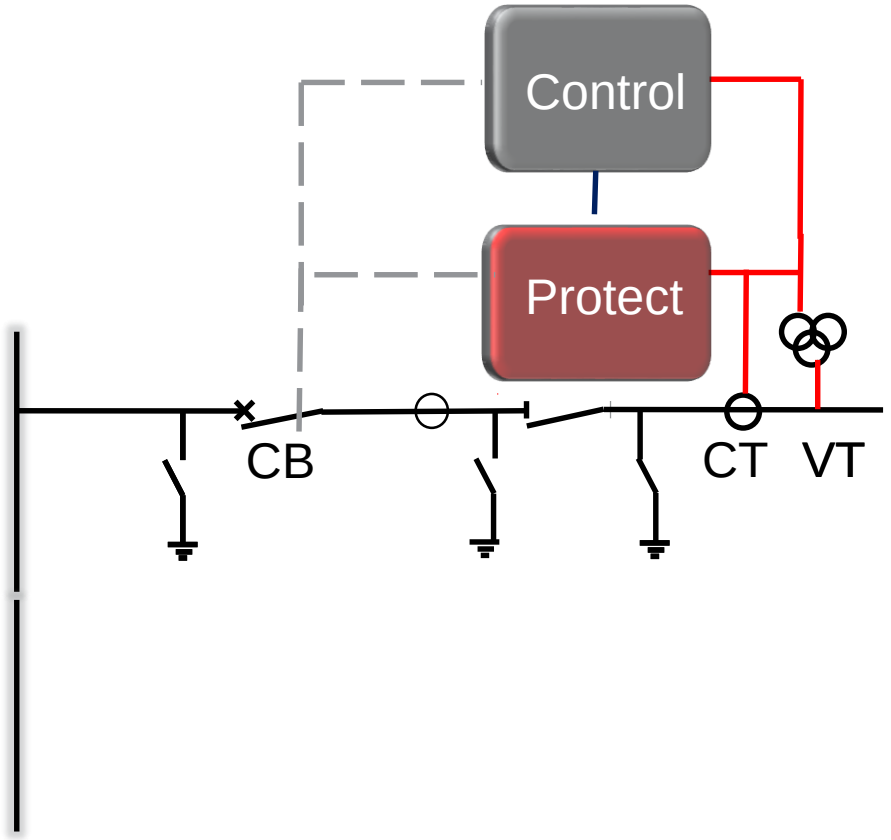


ORGANIZATION
BE PREPARED

- New technologies means new organizational skills
- Implementing and support technologies means long term knowledge
  - Engineering and specialisme in-house
  - Engineering and specialisme outsourced by long term contracts
  - Combination in house /outsourced

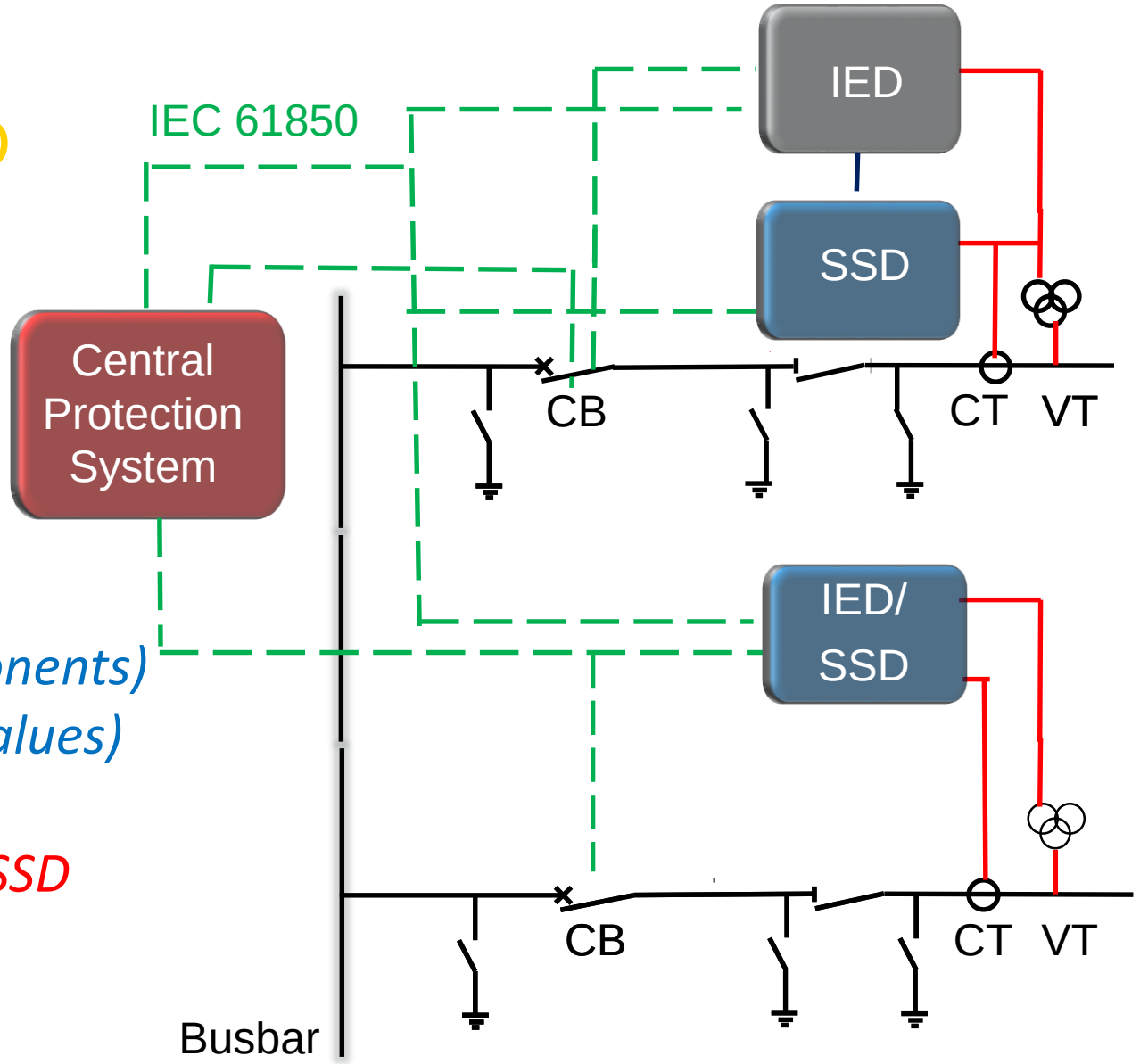
PROTECTION SYSTEM
BASIC

- Current Transformer, CT
- Voltage transformer, VT
- Control/Protection, IED
- Trip circuit
- Circuit Breaker, CB
- Supply

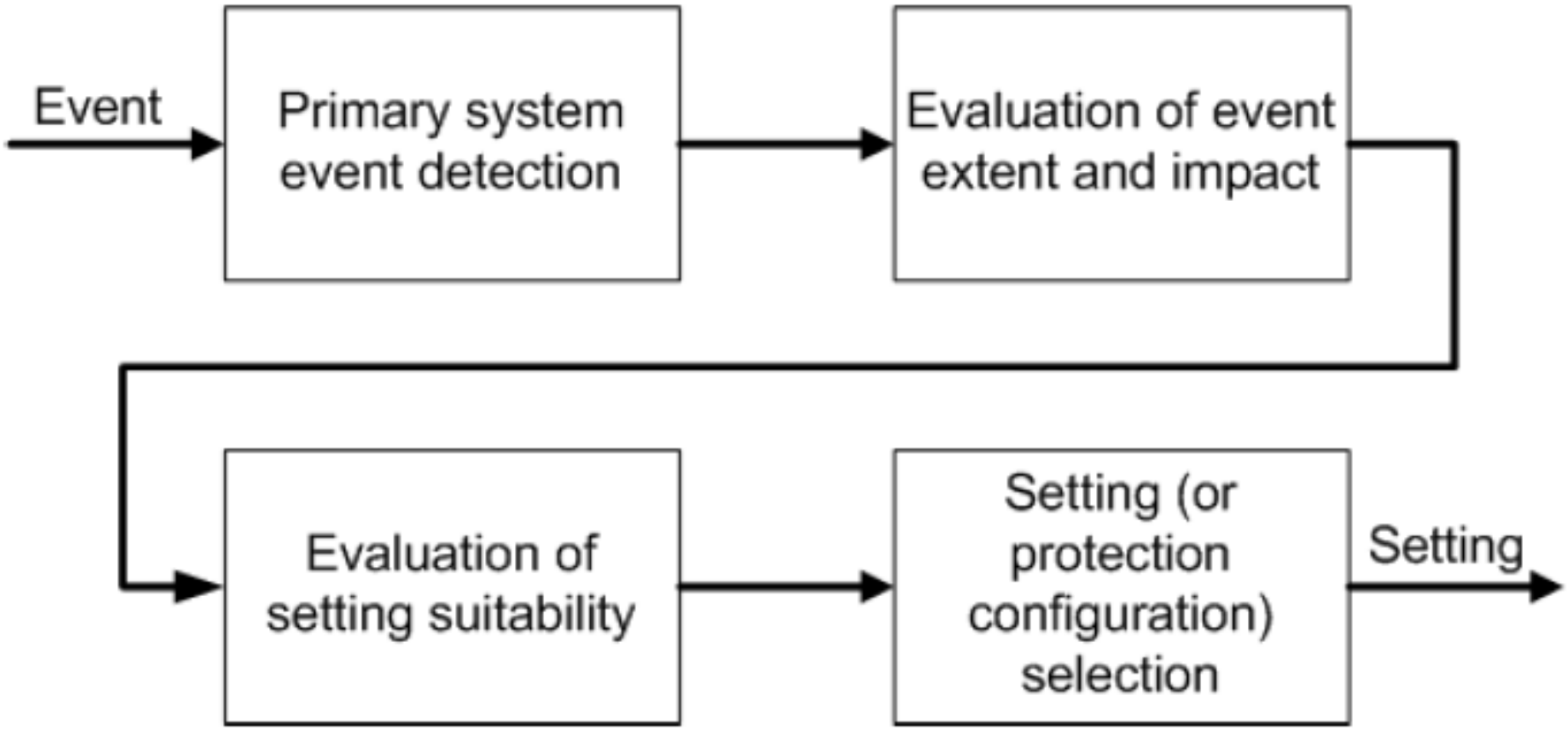


PROTECTION SYSTEM
COMMUNCATION BASED

- IEC 61850 standard
- Standard IED protection
  Detect and trip-output
- Smart Sensor Device (SSD)
  PMU/IED (Symmetrical components)
  Merging Unit/IED (Sampled Values)
- Central Protection System
  Communication with IED and SSD
  Higher performance, back-up



ADAPTIVE PROTECTION
CHANGING SETTINGS REMOTELY



MAINTENANCE

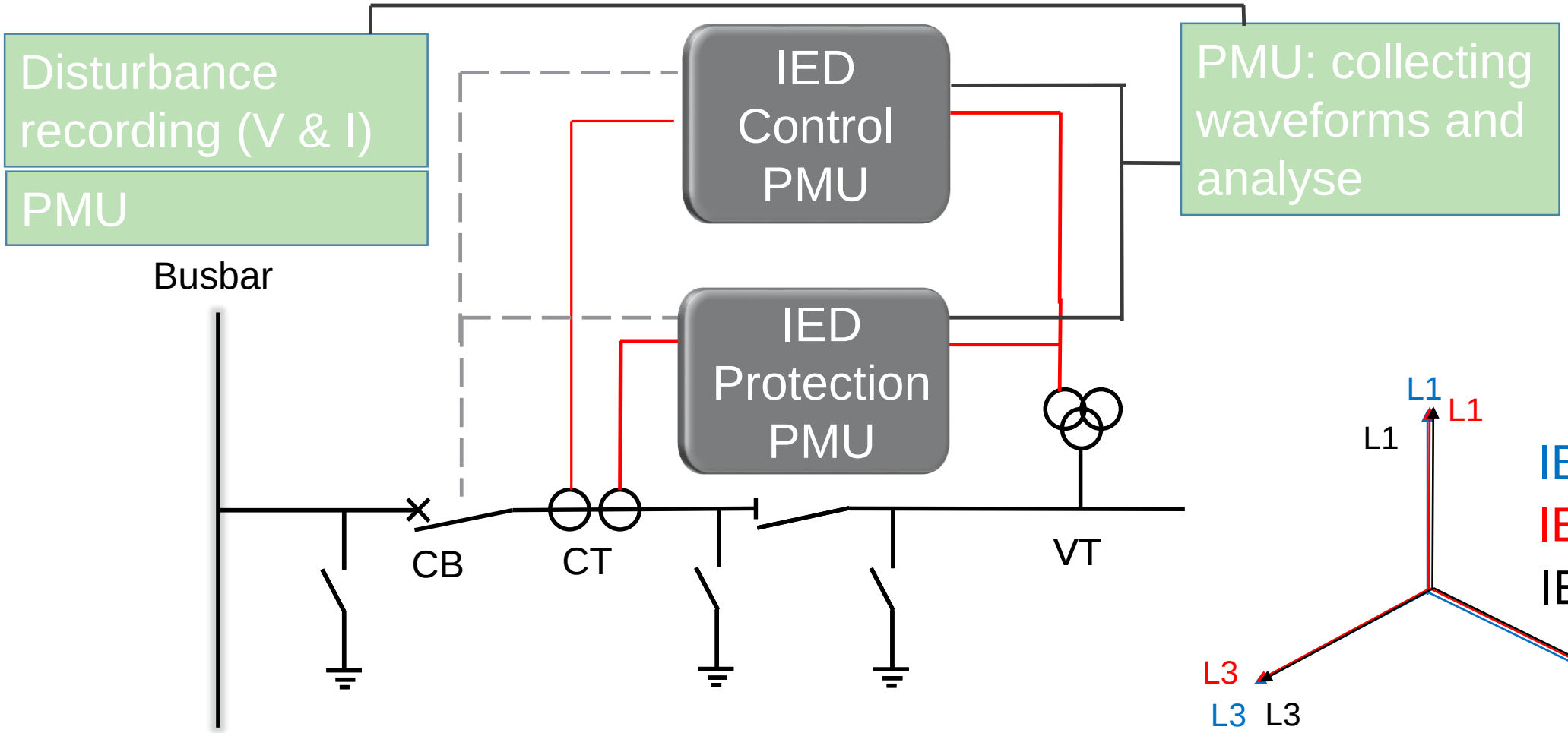
- Condition based (Predictive maintenance)
    - O&M cost reduction, only replace or repair if needed
    - Higher availability IED → less IED's out of service
    - Reducing safety risk → less activities Offshore

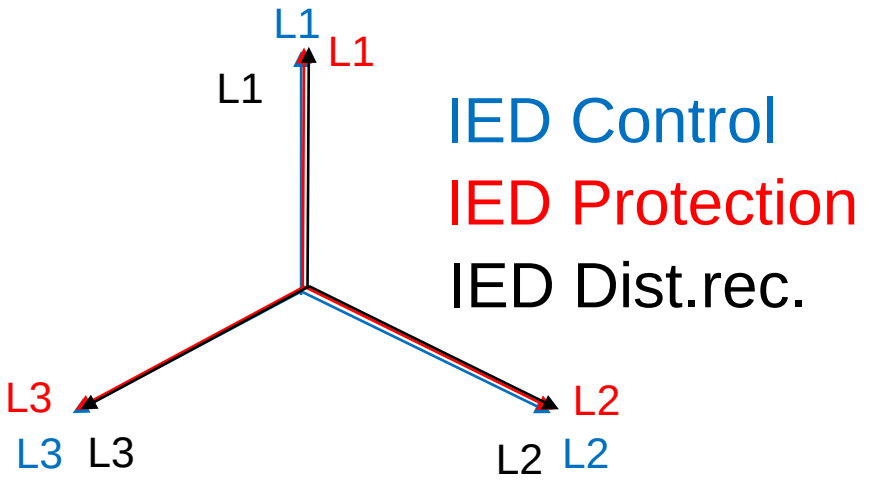
- How?
    - Measuring phasors by PMU's in each IED
    - Benchmark IED inside information (IED-check)

MAINTENANCE
MEASURING PHASORS IN EACH IED

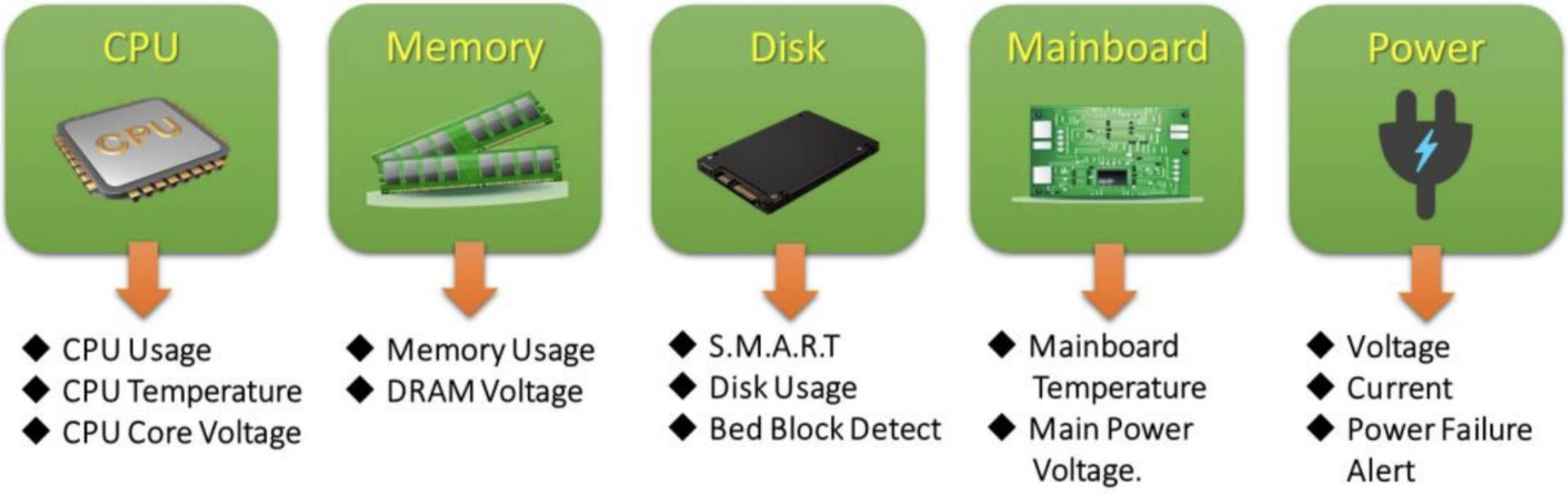
Disturbance recording (V & I)

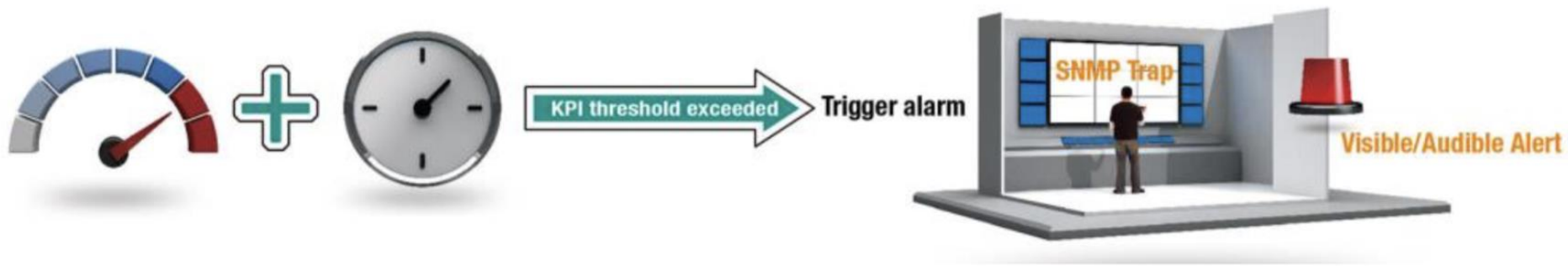
PMU





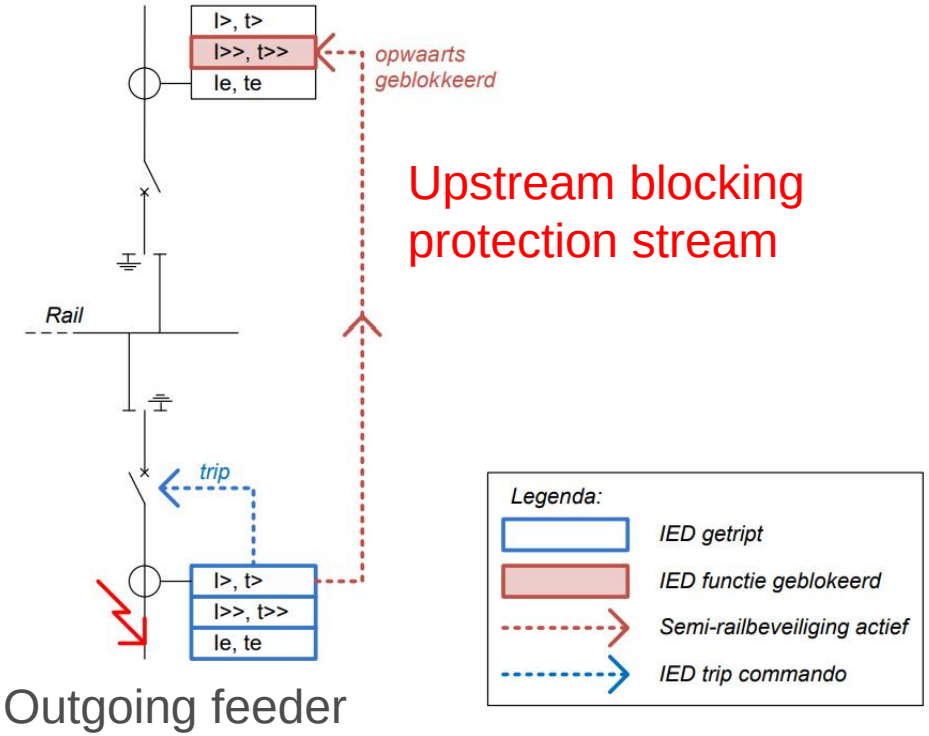
MAINTENANCE





SEMI BUSBAR PROTECTION PRINCIPLE

Incoming feeder

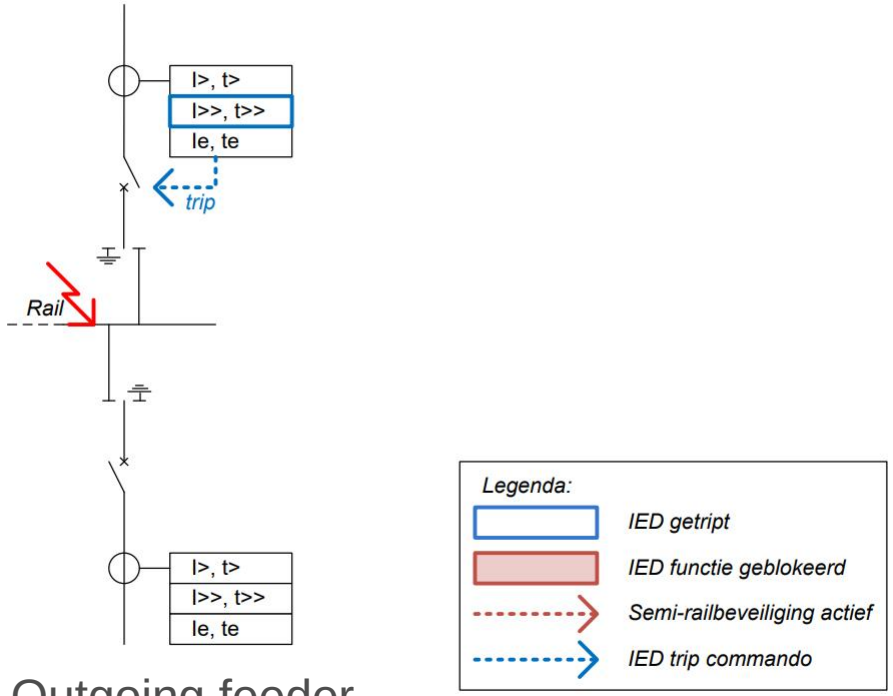


Upstream blocking protection stream

Outgoing feeder

Operation of the protection scheme for a fault in an outgoing feeder

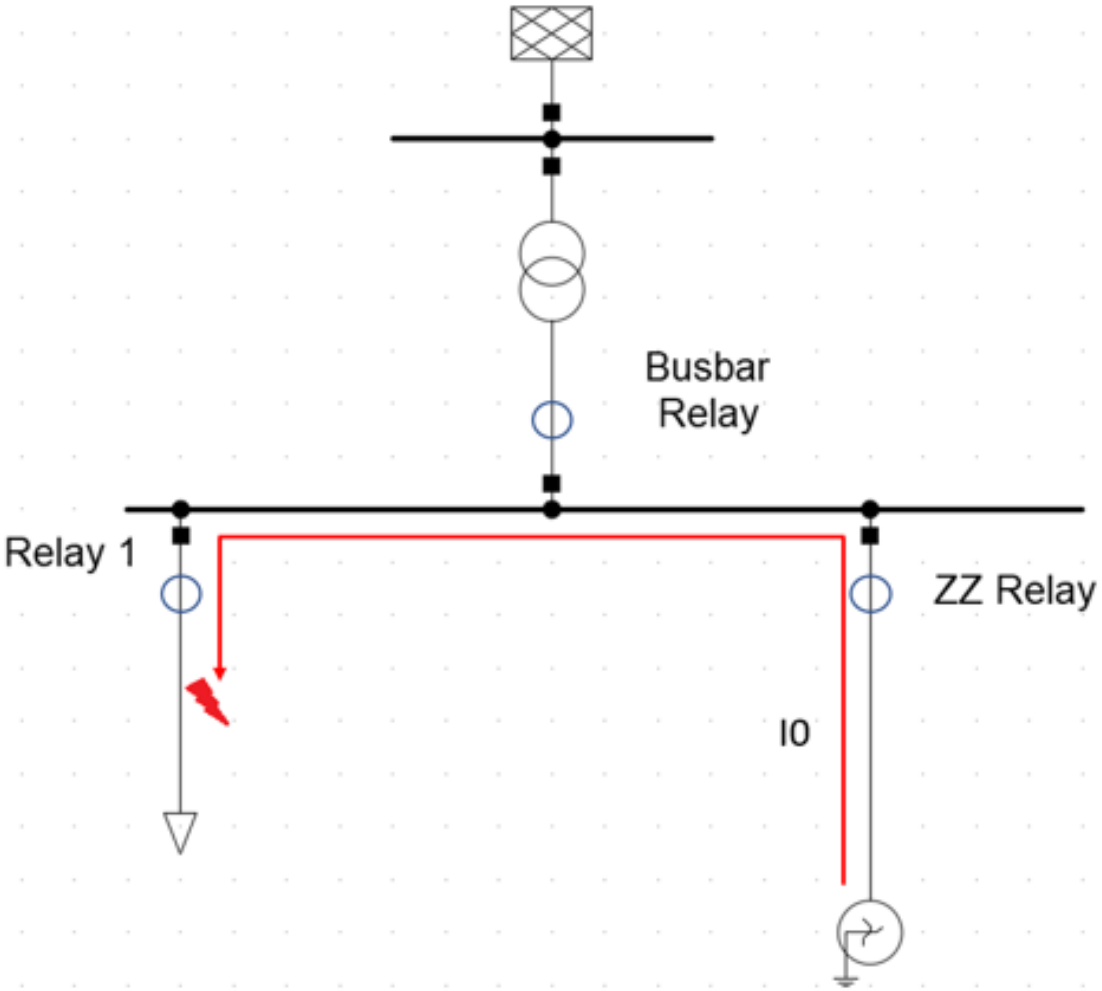
Incoming feeder

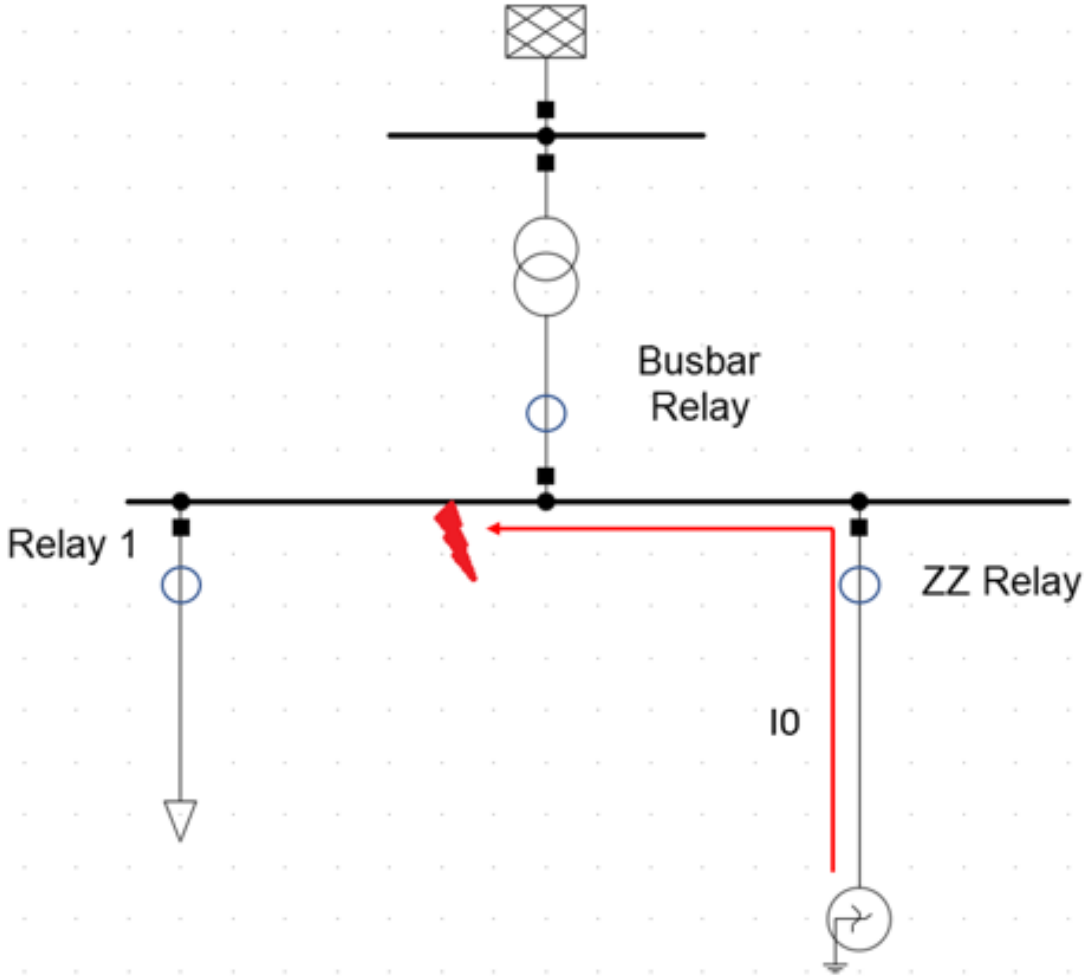


Outgoing feeder

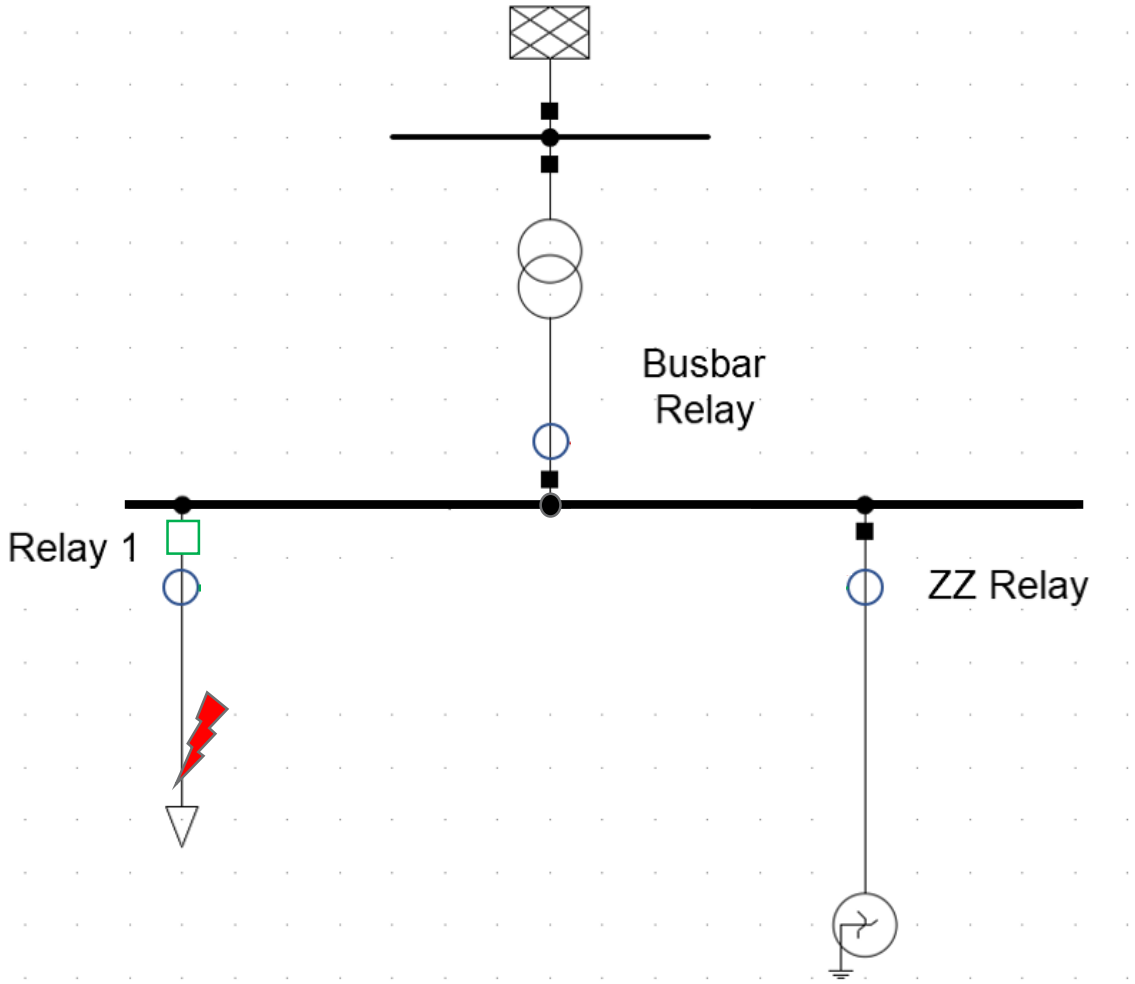
Operation of the protection scheme for a fault on the busbar

Logic single phase fault scheme



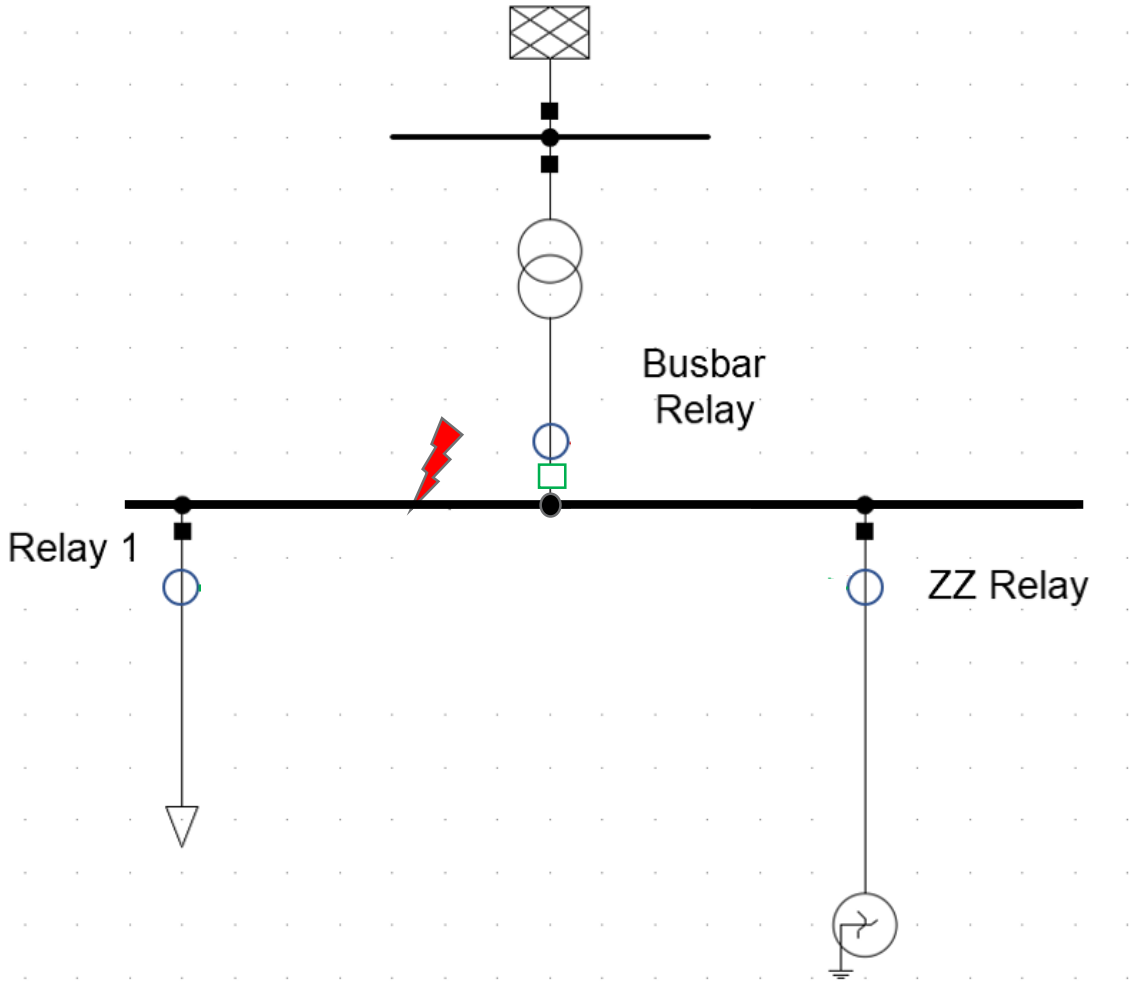


Principle of operation



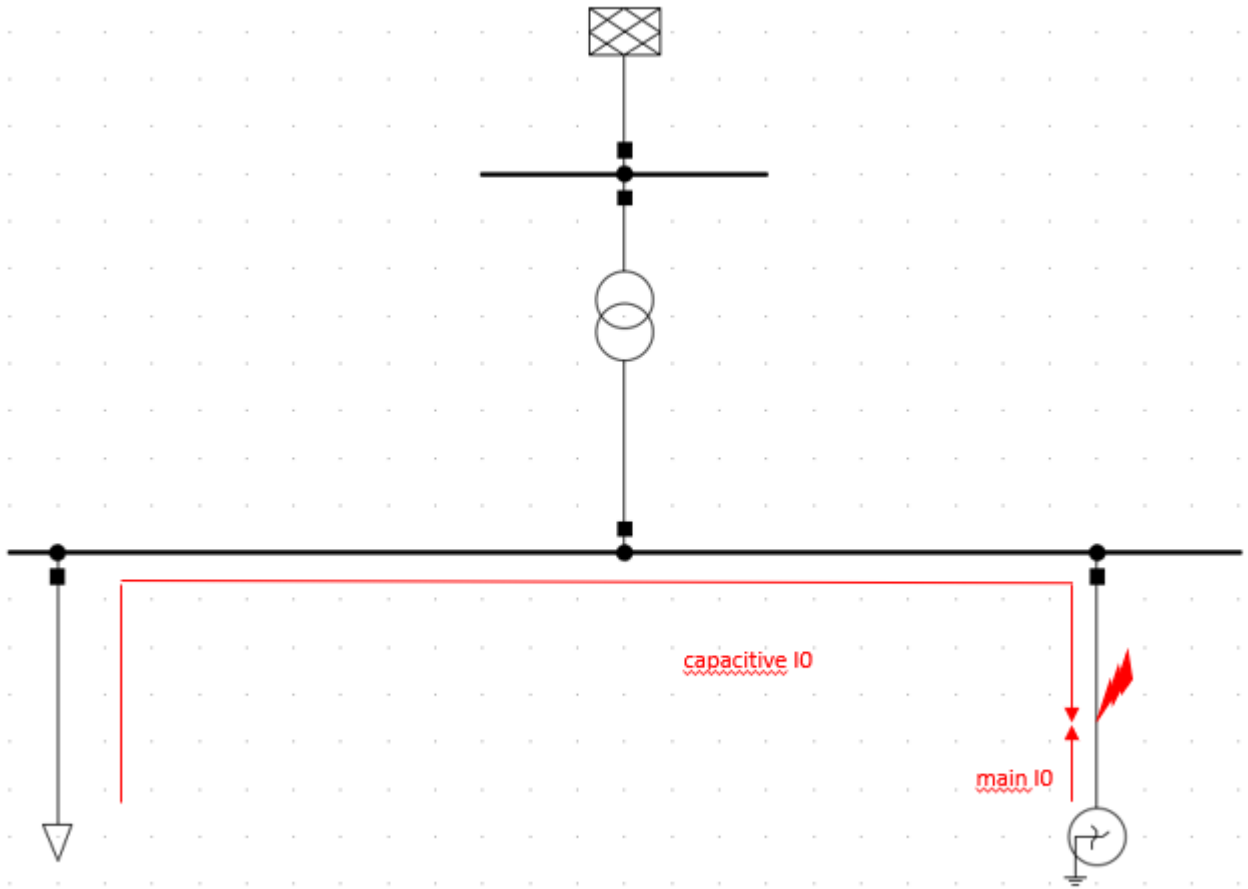
- The outgoing feeders send a BLOCK signal to the ZZ relay when the threshold of their Ie> setting is reached

Principle of operation



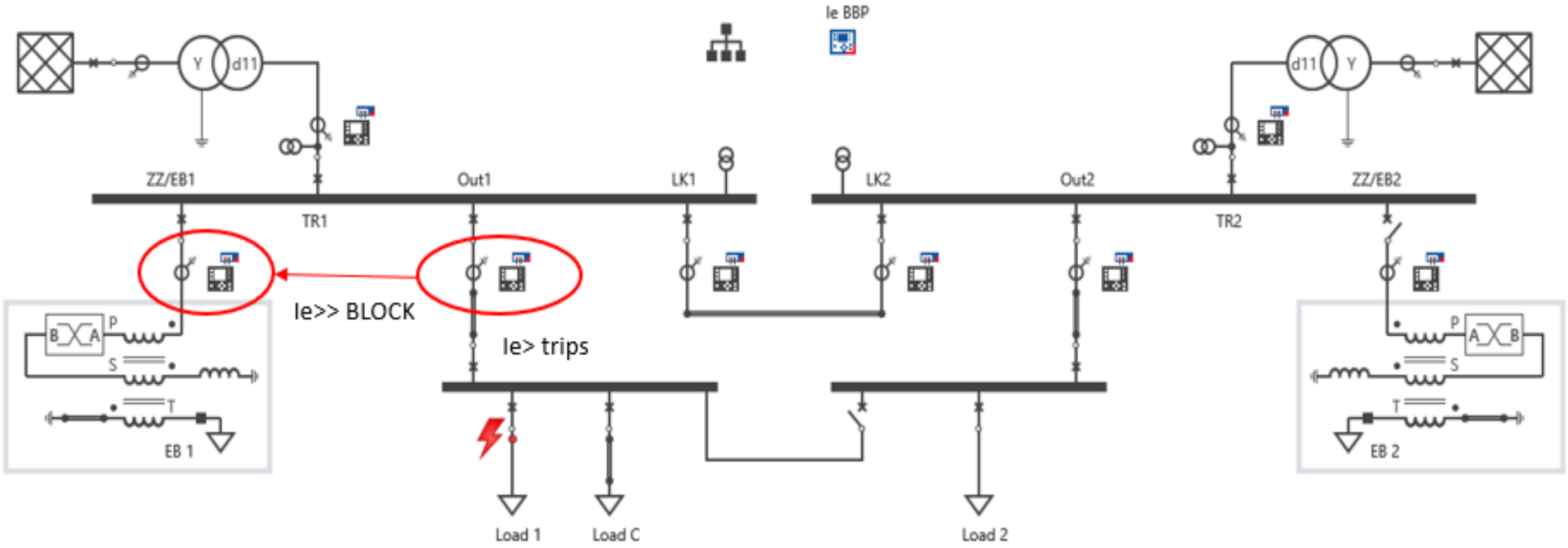
- The ZZ Relay sends a TRIP command to the Busbar Relay when its Ie>> threshold is reached (on the condition that it hasn't received a BLOCK command from the feeders)
- Additionally the busbar Relay needs to detect a zero-sequence overvoltage (0.3*Un) in order for a tripping command to be issued

Consideration for the ZZ feeder

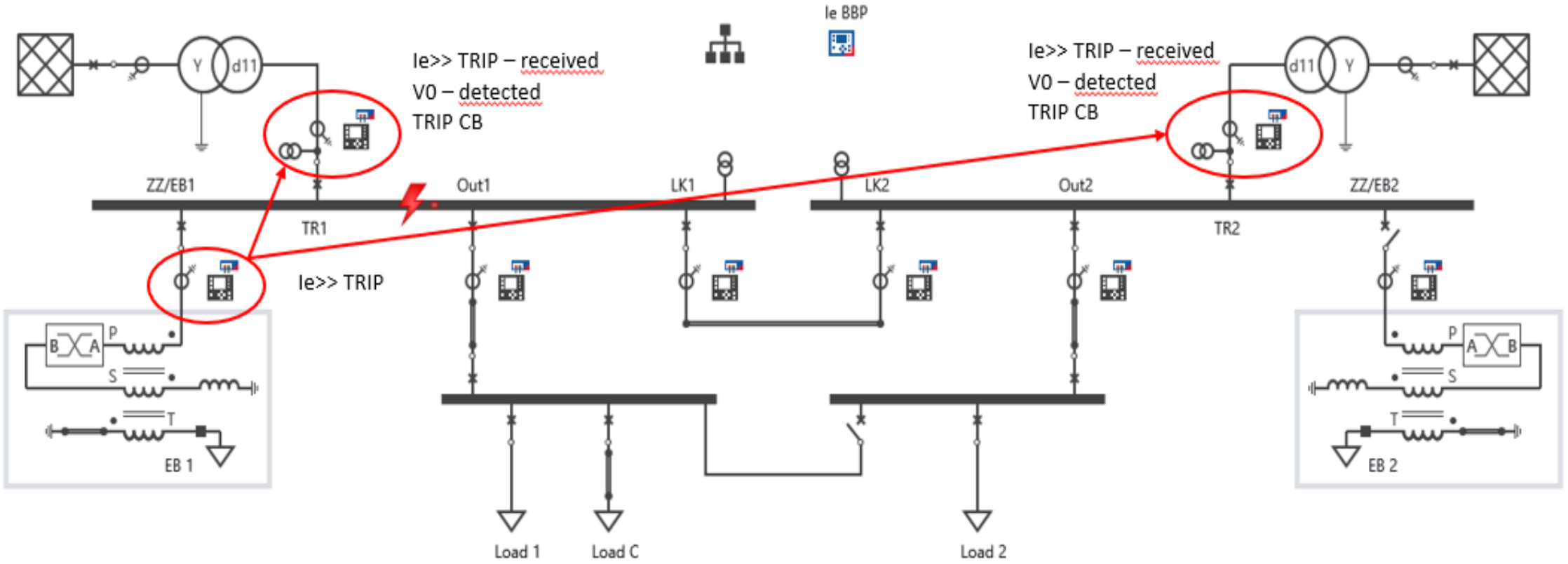


- Only the capacitive I0 passes through the CT on the ZZ feeder – the value is too low in order to protect the ZZ feeder
- For detecting the fault the negative sequence current is used – flows from the sources in the grid towards the point of fault

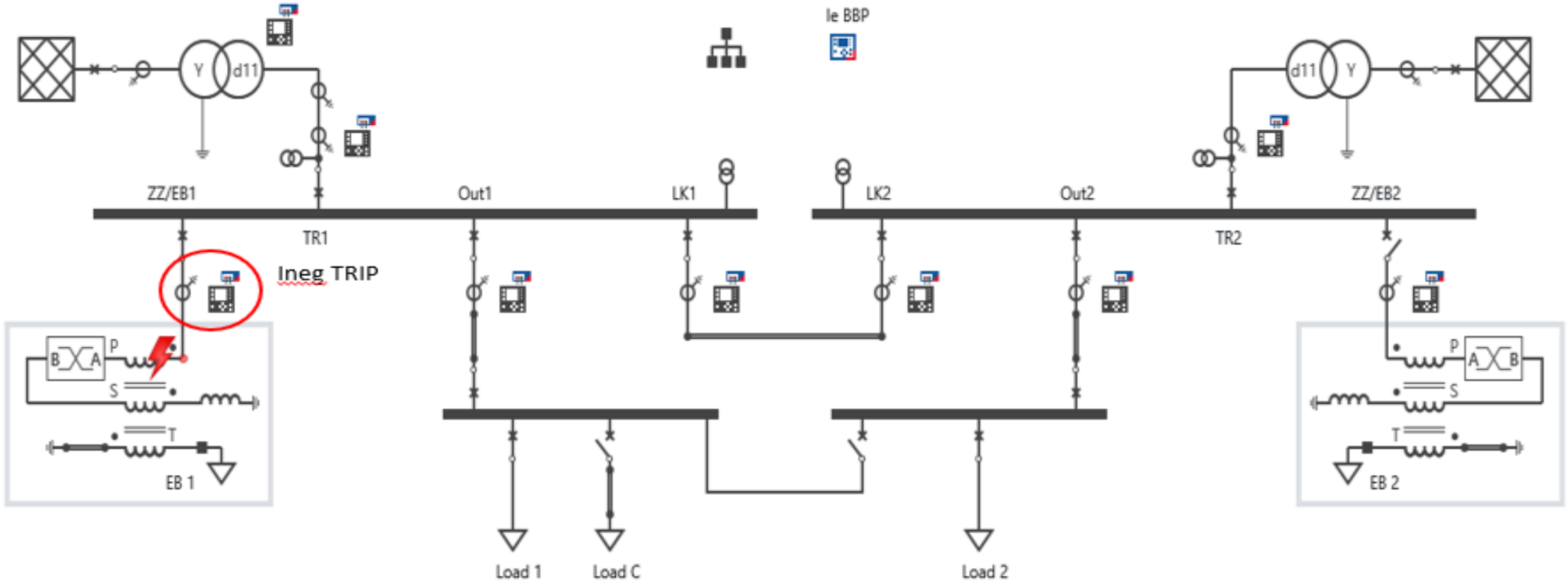
Outgoing feeder fault



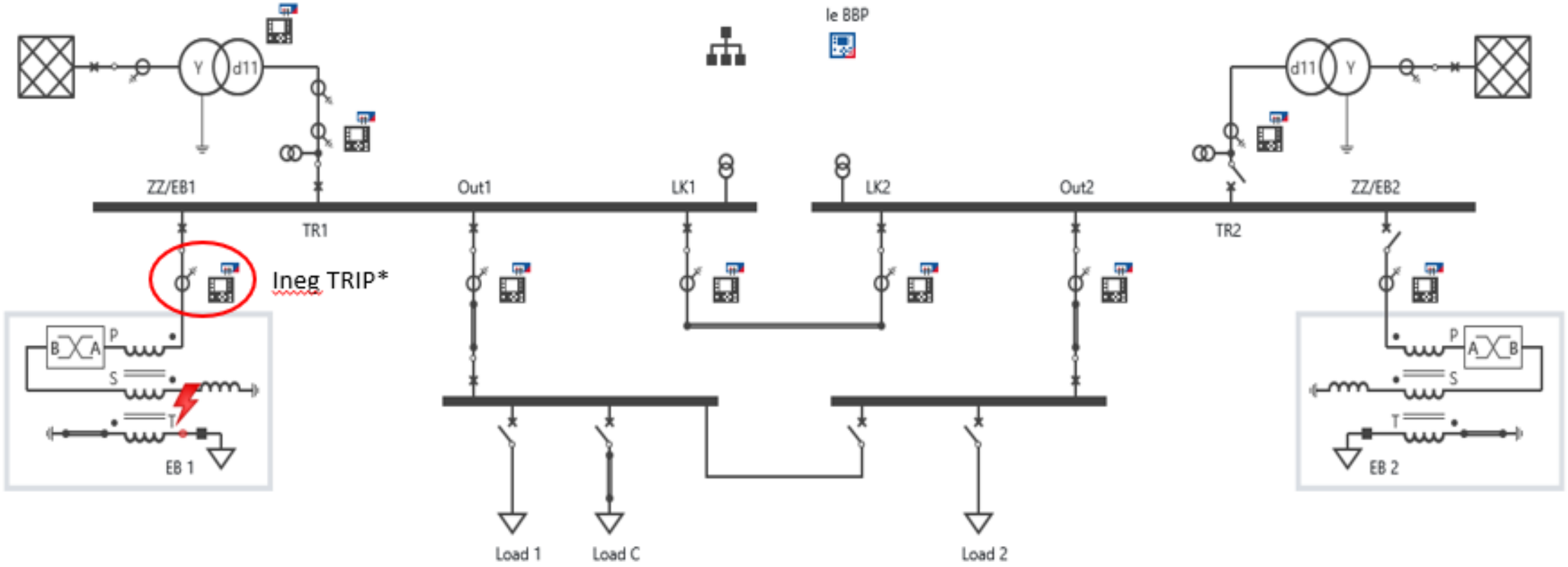
Busbar fault (sectionizer closed) (1)



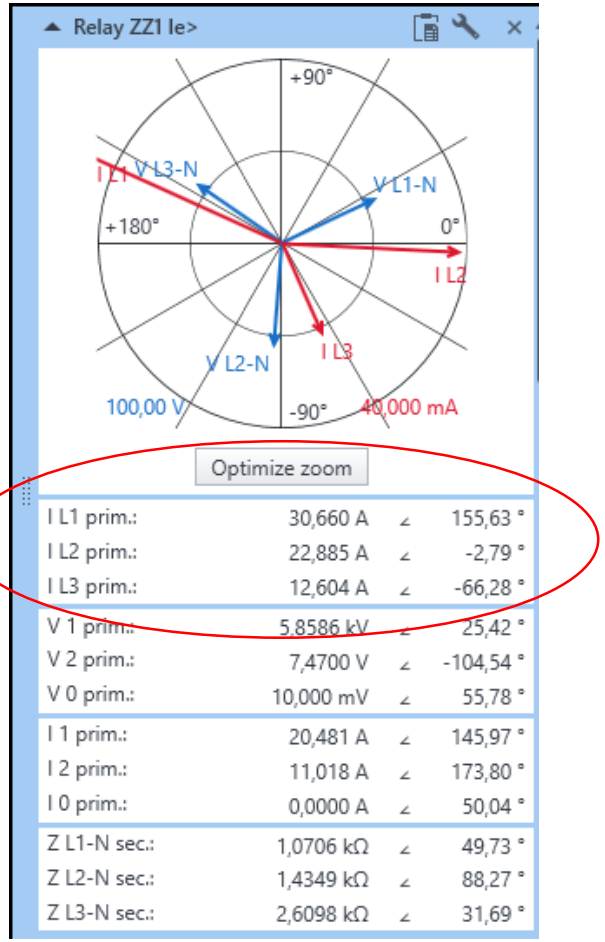
ZZ feeder fault (1)

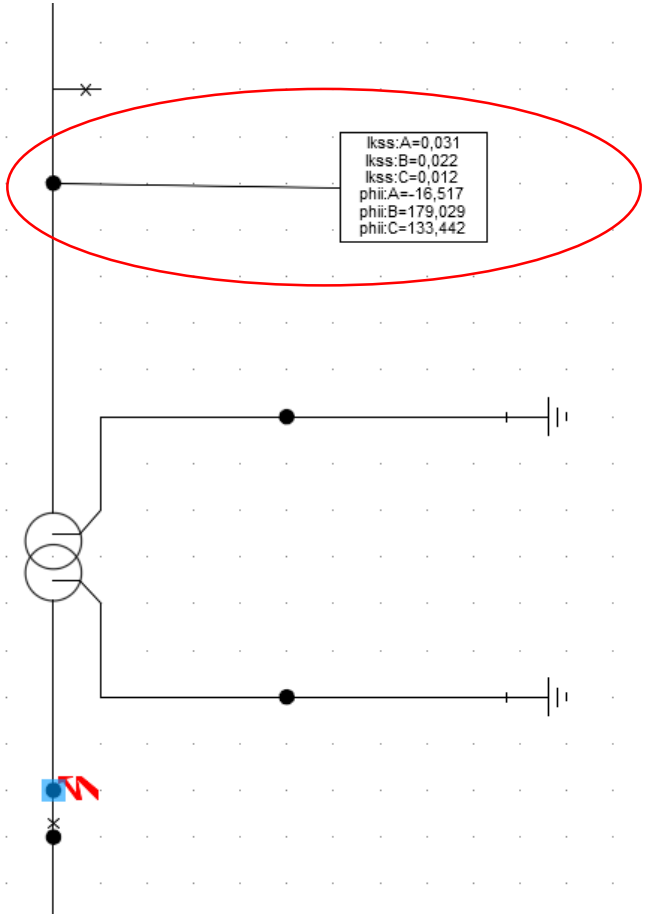


ZZ feeder fault – low voltage side (1)



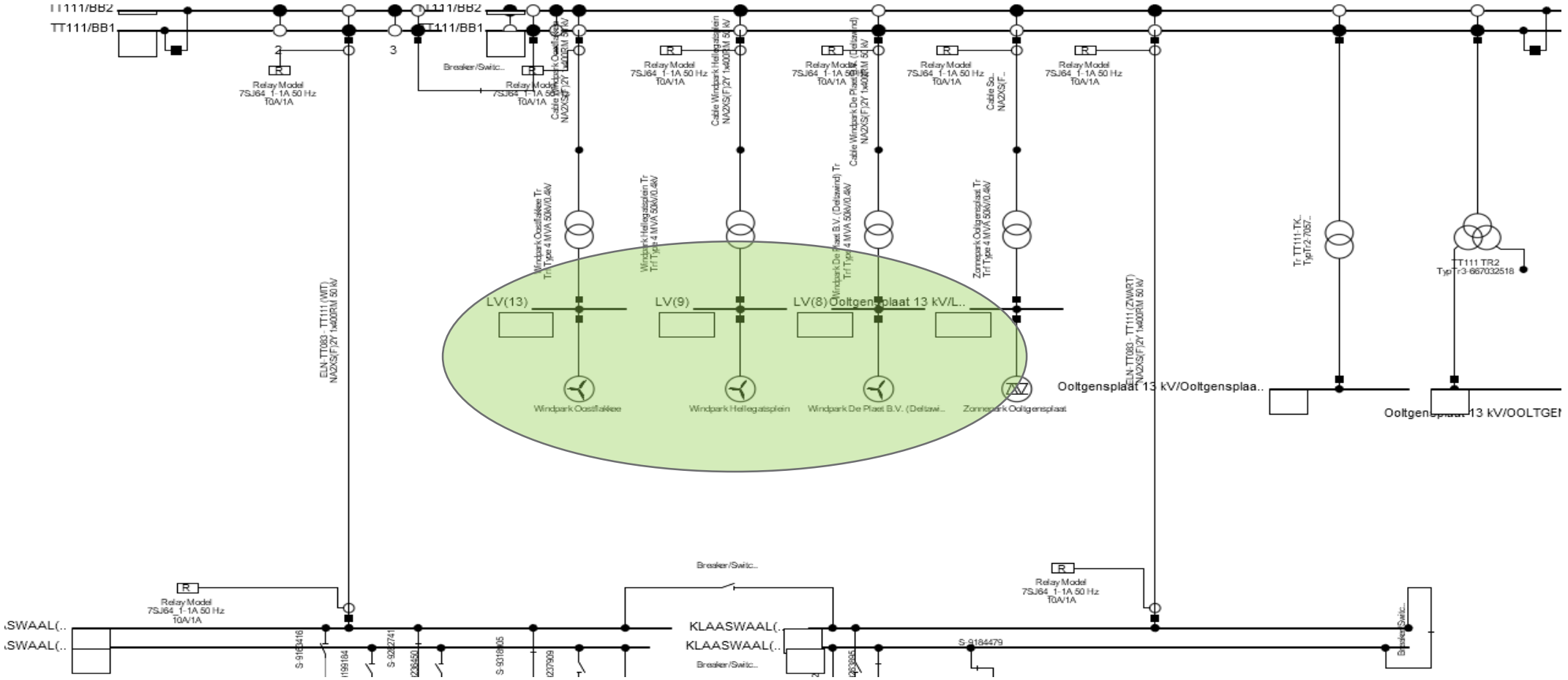
Validation





Both software tools
Relay Sim Test (Omicron) and
PowerFactory (DIgSILENT)
provide similiar behaviour of the
currents

DETECTION OF LOW FAULT CURRENT ON DISTRIBUTION LINES WITH DG



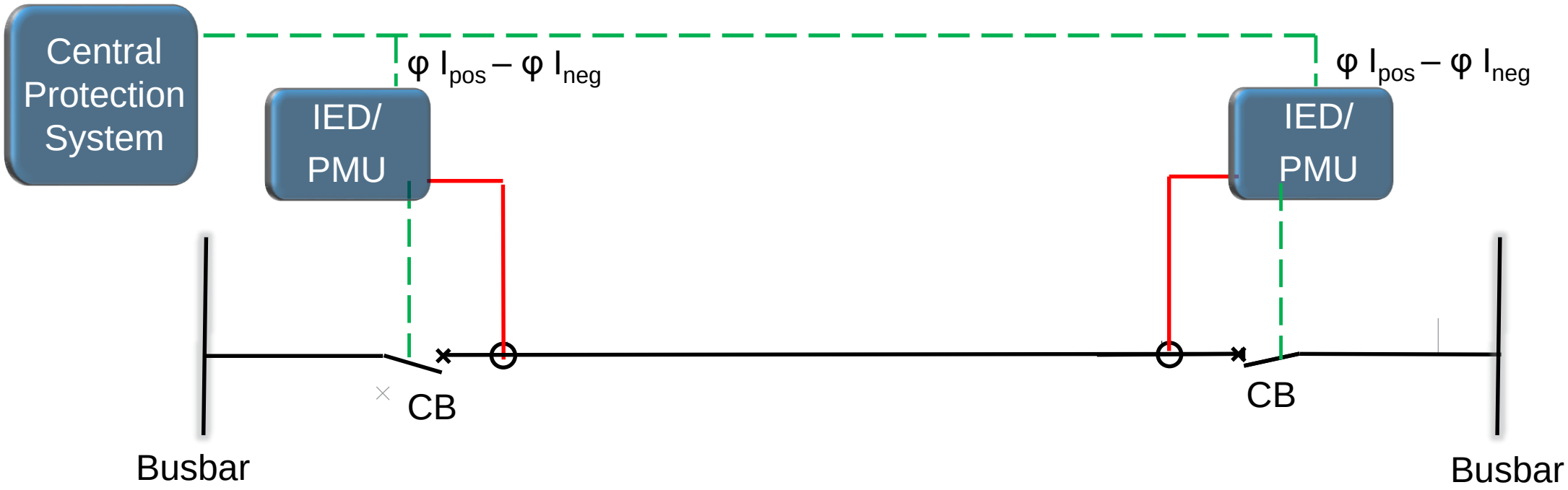
Internship/Thesis Shivesh Chaudhary, student at TUD, supervision M. Popov

DETECTION OF LOW FAULT CURRENT ON DISTRIBUTION LINES WITH DG

- Increase in DG's leading to low contribution of short-circuit current from HV-side of the grid.
- Possible that the short-circuit remains undetected because the grid contribution to the short-circuit current never reaches the pickup-current of the feeder relay.

DETECTION OF LOW FAULT CURRENT ON DISTRIBUTION LINES WITH DG

To detect faulted line: Δφ (delta angle) of positive and negative current < Threshold



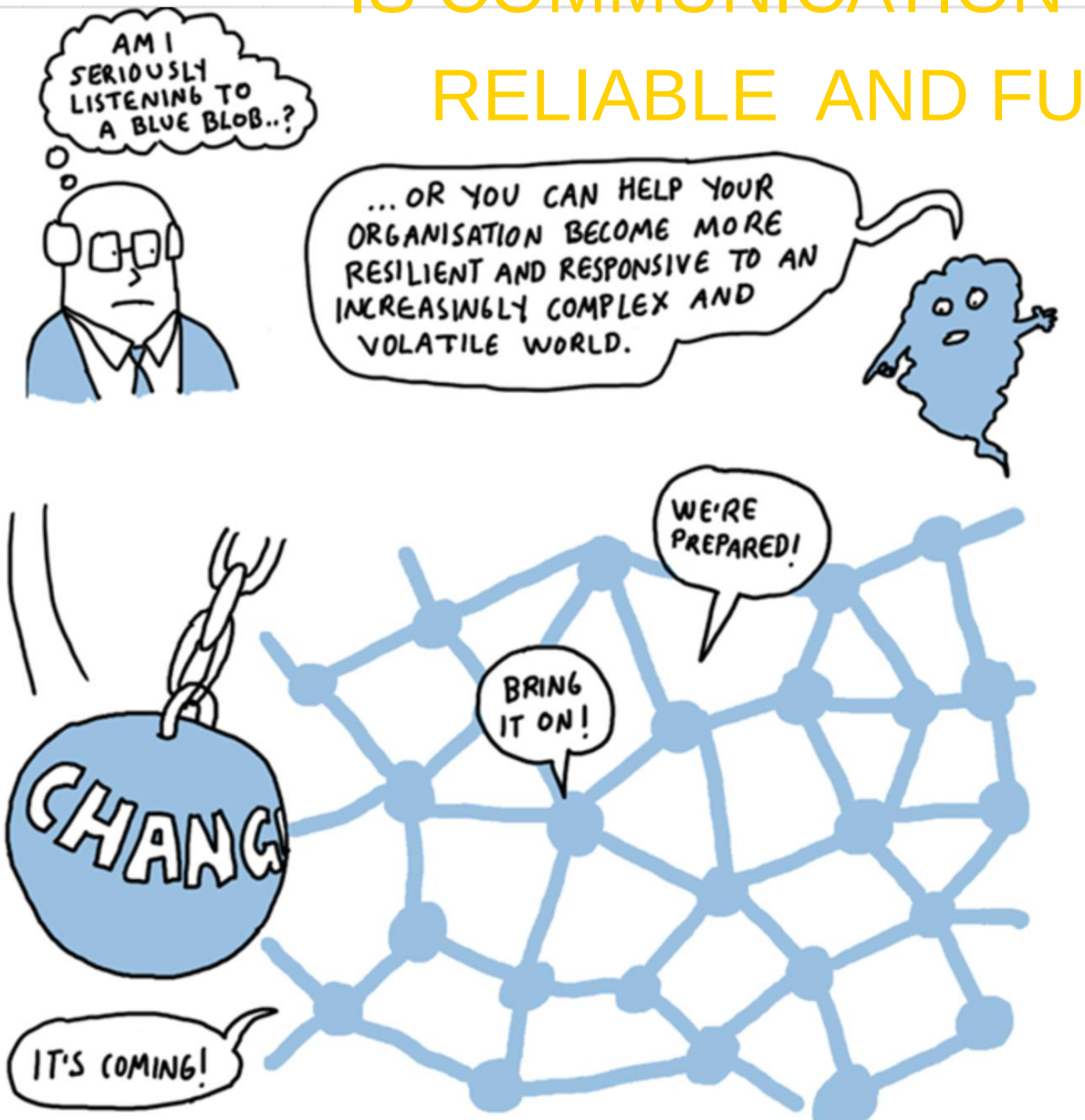
COMMUNCATION BASED PROTECTION

Communication gives smarter protection,
but what if communication fails?

- No mail operation, non-selectivity (design requirement to minimize risk)
- Limited impact with redundant communication
- Gives signaling of failure communication
- Failure finding, need of special skill organization (protection specialist, IT/OT-specialist)

CONCLUSION

IS COMMUNICATION BASED PROTECTION RELIABLE AND FUTURE EFFECTIVE?



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IT DEPENDS

THANKS FOR YOUR ATTENTION

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