

# Next-generation earth-fault protection

Kenneth Bengs, Product line manager

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Earth faults

Network system earthing methods

Compensated network

Earth fault protection in compensated network

New generation earth fault protection: Multi-Frequency Admittance method (MFA)

# Earth fault protection

## Earth fault

### Why is earth fault protection important?

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- Earth faults are the most common fault types in medium voltage distribution networks
- Safety for people and animals
- The demand for the quality and reliability of supply is constantly rising

# Earth fault protection

## Earth fault

### Examples

- Trees touching overhead lines, permanently or temporarily
- Flashover from overhead line to an earthed distribution transformer
- Vehicles touching overhead lines
- Polluted or cracked insulators
- Cable insulation faults caused by aging or physical damage
- Overhead line fallen to ground



# Earth fault protection

## Network system earthing

### Effectively earthed (1)

Also called "Solidly" earthed

High fault current

EF protection, low complexity

### Low impedance (2)

Typically earthed with a resistor

Medium fault current

EF protection, low complexity

### Compensated (3)

Also called "Petersen coil" or resonant earthed

Minimal fault current  
Overvoltage in healthy phases

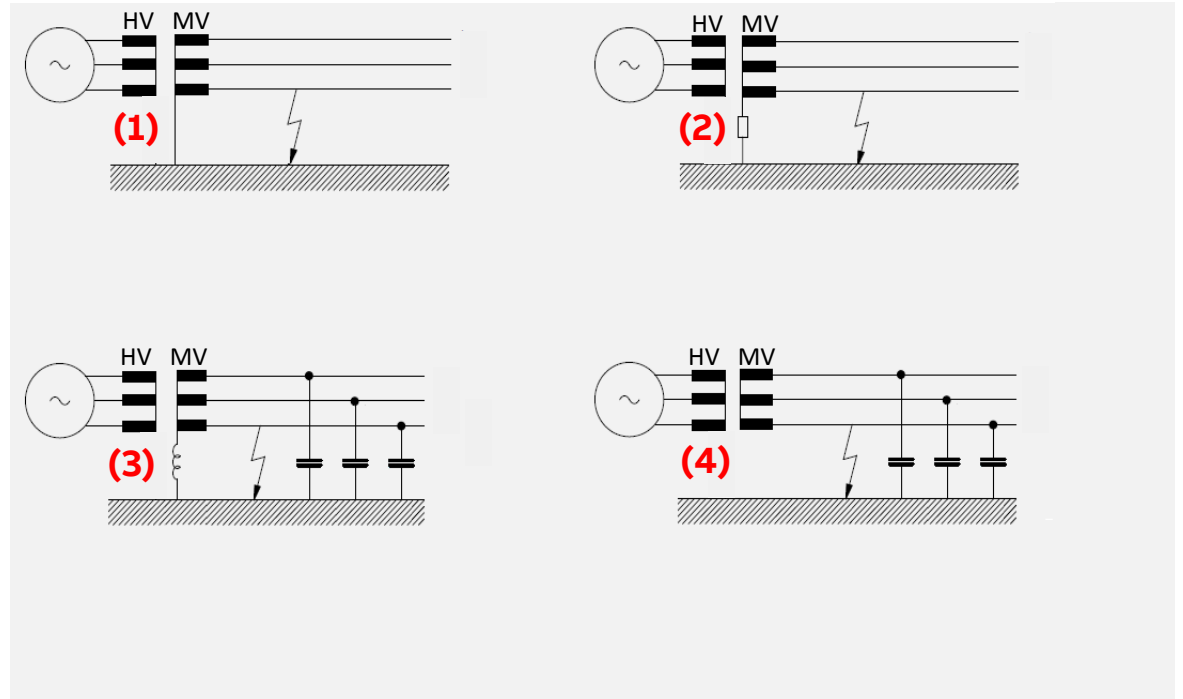
EF protection, high complexity

### Unearthed (4)

Also called "Isolated"

Low fault current  
Overvoltage in healthy phases

EF protection, medium complexity

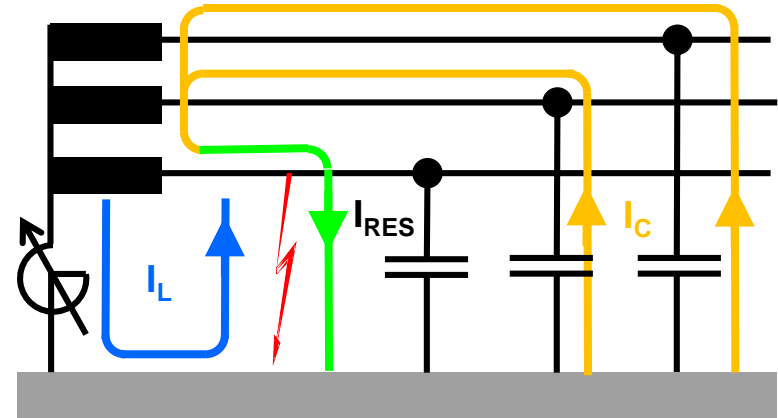


# Earth fault protection

## Compensated network

### Benefits

- Earth fault current is reduced to minimum
- Does necessarily not require immediate trip of the faulty feeder if touch and step voltages are low enough
- Arcing faults are typically self-extinguished
- Less power interruptions



# Earth fault protection

## Compensated network

### Trends towards compensated networks

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- The interest of compensated networks is increasing globally due to operational and safety benefits
- Climate change driven
  - Storms in Nordic countries during last decades
  - Bush fires in Australia



# Earth fault protection

Compensated networks (utility distribution networks)

## Examples of countries using compensated networks

- Australia (piloting)
- Austria
- China
- Czech republic
- Denmark
- Estonia
- Finland
- France
- Germany
- Russia
- Slovakia
- Sweden
- Many countries with unearthed may shift to compensated





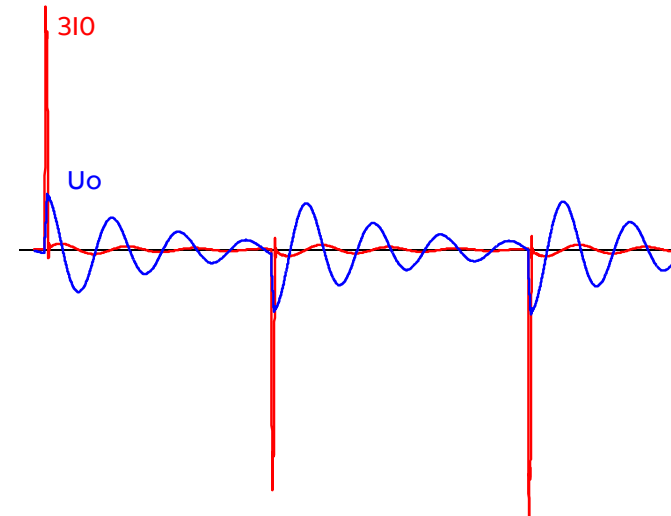
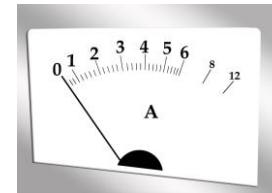
# Earth fault protection

## Compensated network

### Protection challenge

Despite clear operational benefits with compensation, reliable earth fault protection is more challenging

- The fault currents are low and more difficult to detect
- Restriking (intermittent) earth faults



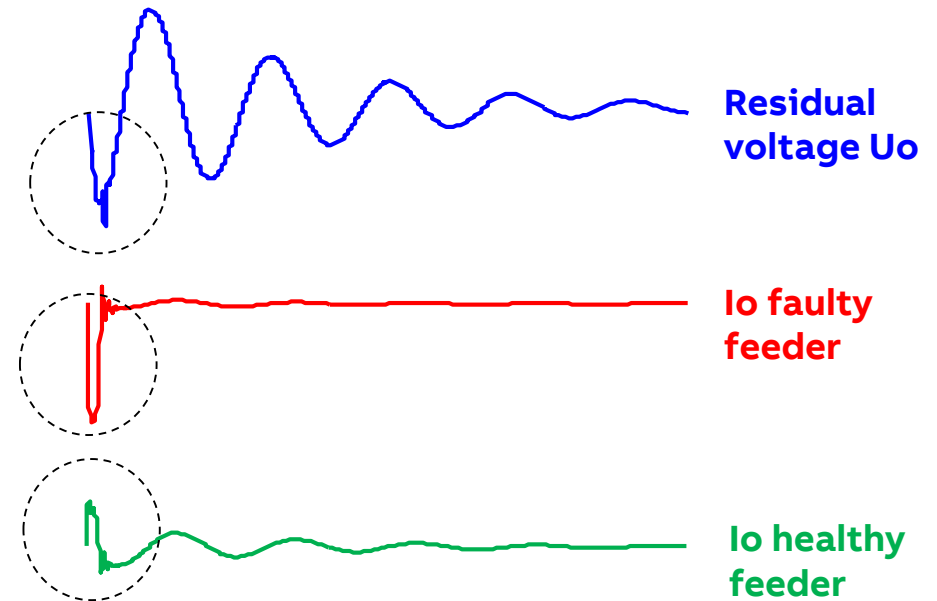
# Earth fault protection

## Compensated network

### Conventional transient based protection

#### Challenges

- Comparison of the polarities of earth fault transients
  - Variation of transient magnitude and frequency
  - Disturbances in transients
- Risk of unselective operations and in worst case disconnection of an entire primary substation
- Requires special hardware
  - Expensive to invest in dedicated protection relays

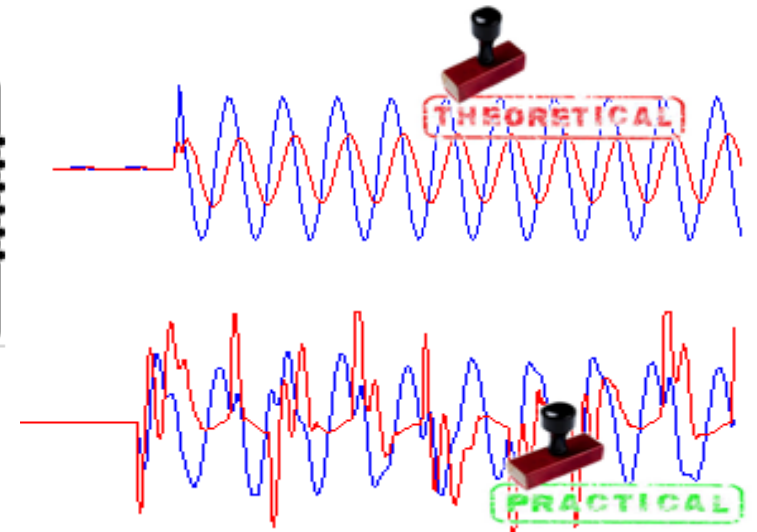
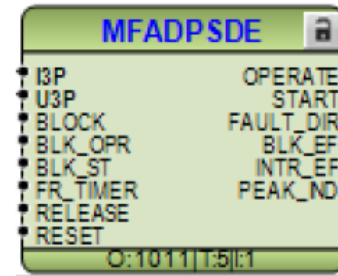


# Earth fault protection

## Compensated network

### User needs and next generation offering

- The distribution network operators (DNO) have for many decades been waiting for a **reliable and cost efficient earth fault protection** in compensated networks
  - This has become even more crucial, with the trend of increasing number of compensated networks globally
- **Our new unique Multi-Frequency Admittance protection function is the solution with an outstanding fault detecting capability and reliability**
  - Based on our deep theoretical understanding of earth fault phenomenon
  - Complemented with practical knowledge gained from numerous field tests and comprehensive disturbance analysis



# Earth fault protection

## New generation

### Multi-Frequency Admittance

All major challenges have been solved in our novel approach

**Challenge 1:** non-sinusoidal waveforms

**Solution:** Utilization of harmonics

**Challenge 2:** Intermittent characteristics

**Solution:** Utilization of Cumulative Phasor Summing (CPS)

**Challenge 3:** Sensitivity of protection

**Solution:** Admittance calculation, utilization of fundamental frequency

**Challenge 4:** Changes in network compensation degree

**Solution:** Extended operation characteristics



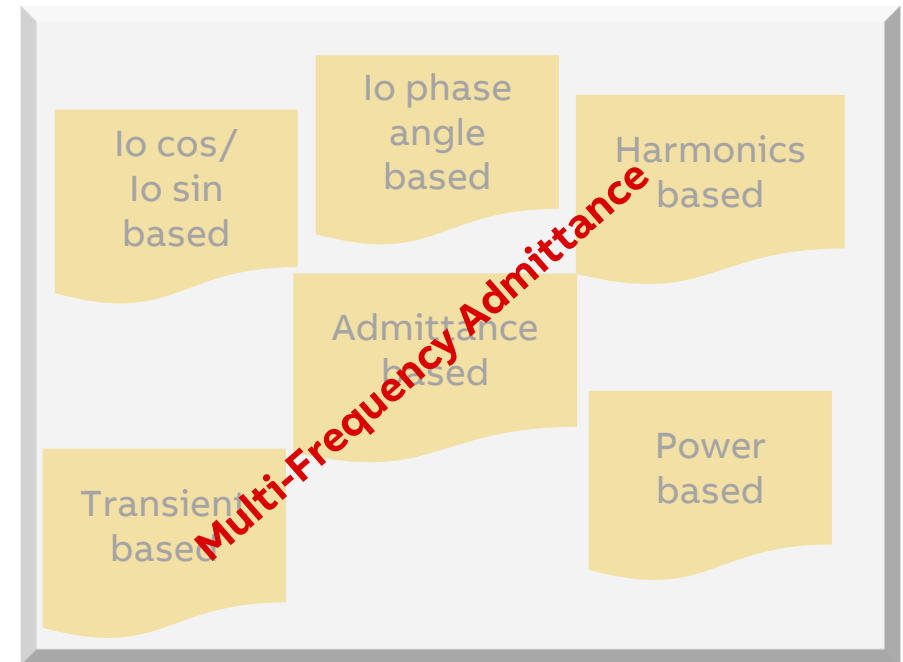
# Earth fault protection

## Multi-Frequency Admittance

### Full application coverage

One protection function MFADPSDE with full application coverage

- Used in compensated and unearthed networks
- For cable and overhead lines
- Senses low ohmic and high ohmic earth faults
- Detects all earth fault types
  - Permanent
  - Transient
  - Intermittent
- Fault direction indication for easy fault location
- High reliability and selectivity

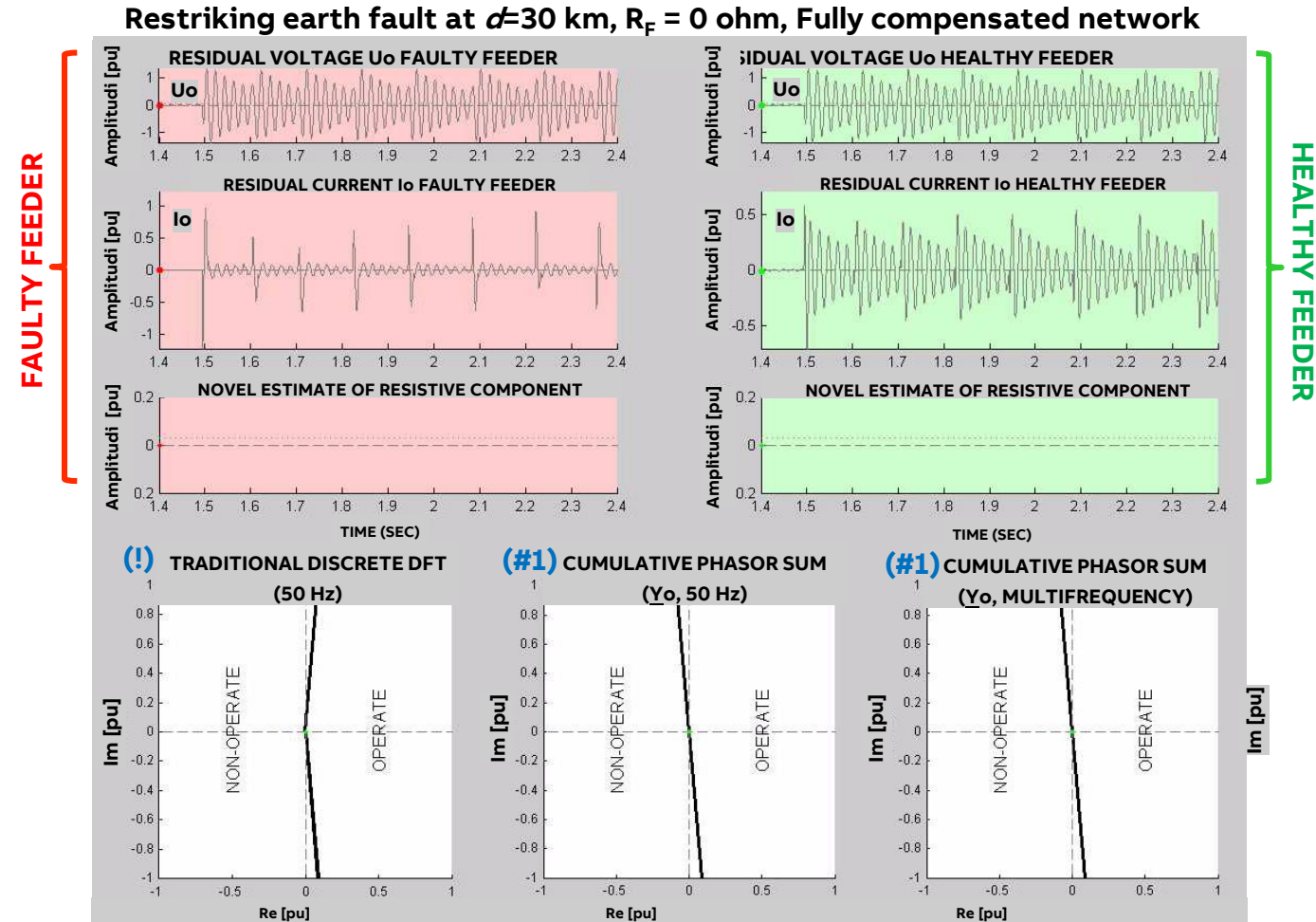


# Earth fault protection

## Multi-Frequency Admittance

### Outstanding performance

- Multi-Frequency Admittance (#1) ensures:
  - Detection of fault in faulty feeder
  - No activation in healthy feeder and gives information of fault seen in backward direction, i.e. there is a fault in another feeder
- Traditional method (!) is risking:
  - Unselective trip of healthy feeders
  - Lack of fault detection or a delayed operation in faulty feeder



# Earth fault protection

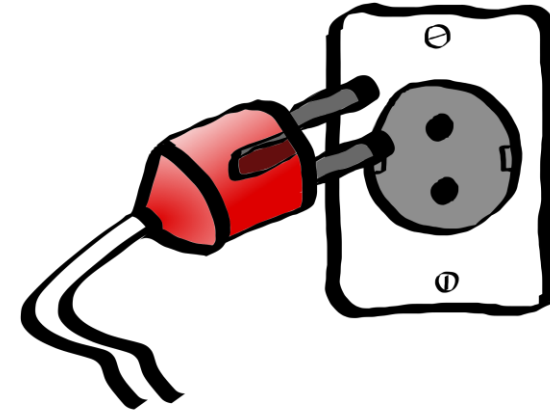
## Multi-Frequency Admittance

### Simplicity

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Easy to engineer and use

- One device, everything integrated into the feeder protection relay
- One protection function to handle
- Easy to define setting values by using basic network data
- Same protection characteristic can be used for compensated and unearthed networks
- Easier commissioning and system integration



*integration simplicity*



# Earth fault protection

## Multi-Frequency Admittance

### Cost efficient

- Part of normal feeder protection relay
  - No additional protection systems or single function protection relay are needed
- Less investment costs
- Less maintenance costs
- Less training of engineers and operators needed
- Less risks in the operation of the network



# Earth fault protection

## Multi-Frequency Admittance

### Summary

**One protection function that covers all with high reliability, selectivity and sensitivity**

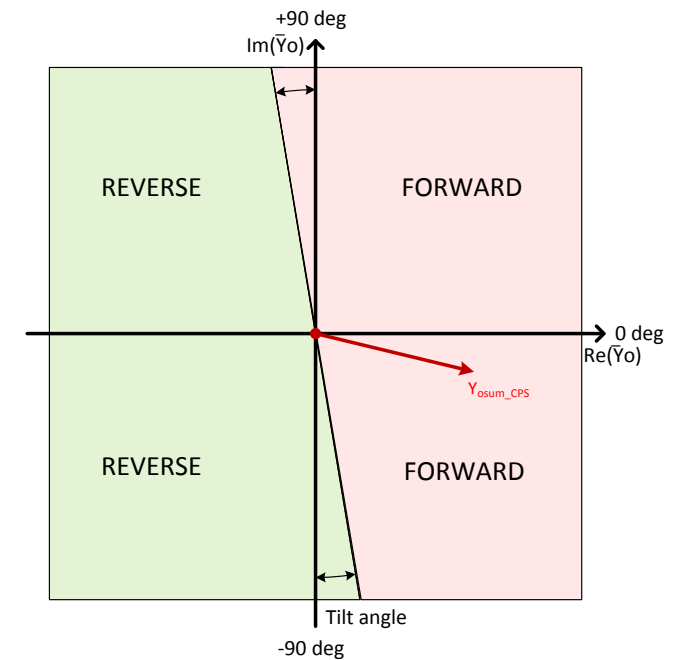
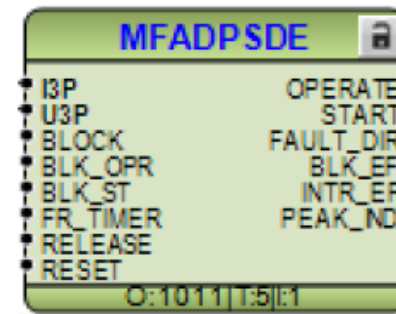
- Used in compensated and unearthed networks
- Low ohmic and high ohmic earth faults
- Permanent, transient and intermittent earth faults

### Easy to use

- One protection function
- Basic network data to be used for settings
- Same characteristic for compensated and unearthed networks
- Fault direction indication for easy fault location

### Part of normal feeder protection relay

- Very cost efficient
- No extra protection systems or single function protection relay are needed

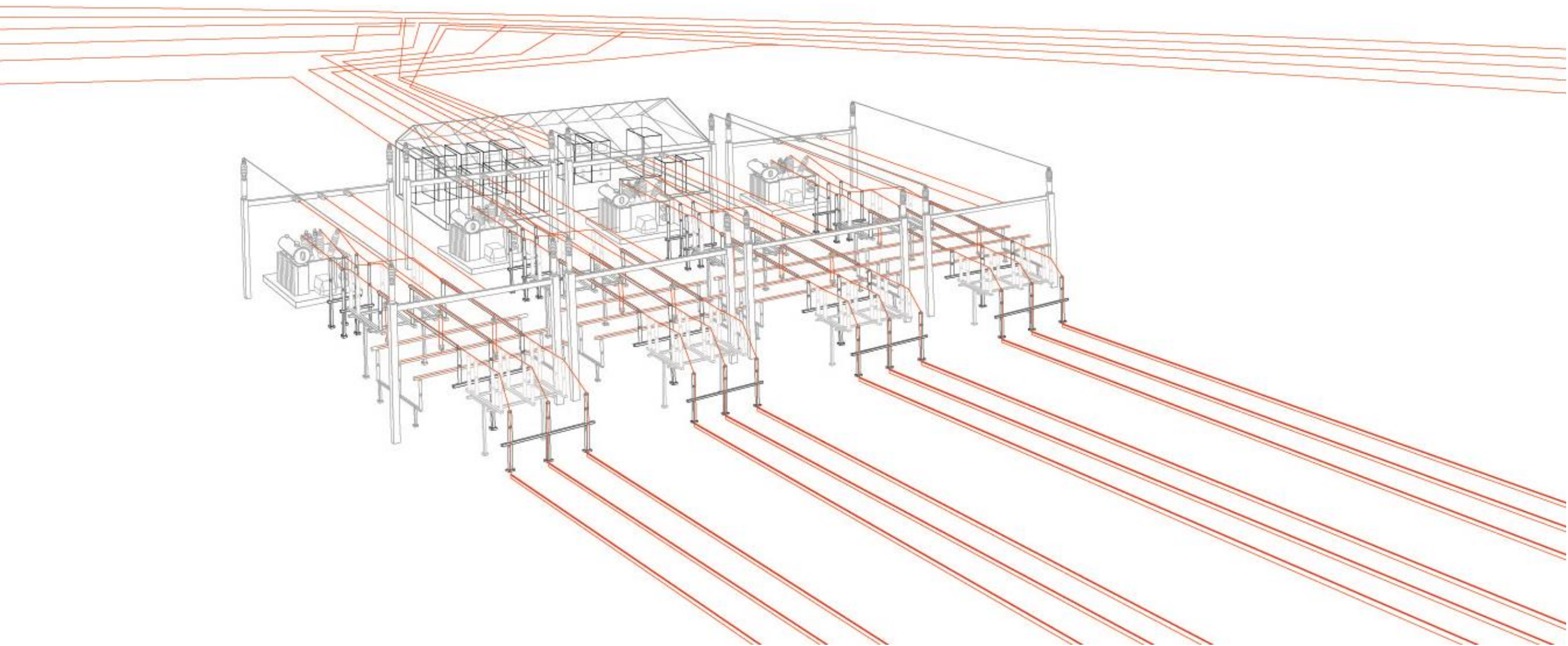


# Earth fault protection

Multi-Frequency Admittance offering

Relion® product family

|                            | 615 series   | 620 series  | 630 series  | RIO600  |
|----------------------------|--|---|---|---|
|                            |  |  |  |  |
|                            | REF615 5.0 FP1<br>L and N  | REF620 2.0 FP1  | REF630 1.3  | RIO600 1.7<br>SIM8F   |
| Application                | Feeder protection  | Feeder protection   | Feeder protection   | Fault passage indication  |
| Multi-Frequency Admittance | Yes  | Yes   | Yes   | Yes   |





**ABB**