

PUBLIC

 DISTRIBUTION AUTOMATION PRODUCT

Basic knowledge of protection relay

ABB Protection relay and solution





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Basic knowledge of protection relay

Objective

- ❑ Protection purpose and requirements
- ❑ Key terminology
 - Selectivity
 - Sensitivity
 - Stability
 - Back-up protection
 - Dependability and security
 - Protected zone
- ❑ Time coordination and grading
- ❑ Types of faults
- ❑ ABB protection and solution



Protection purpose and requirements

Protection purpose and requirements

The basics

Protection purpose

- Detect electrical faults and disturbances
- Protect people and property

Protection requirements

- Sensitive
- Fast
- Selective
- Full coverage
- Reliable

Key terminology

- Selectivity
- Sensitivity
- Stability
- Back-up protection
- Dependability and security
- Protected zone

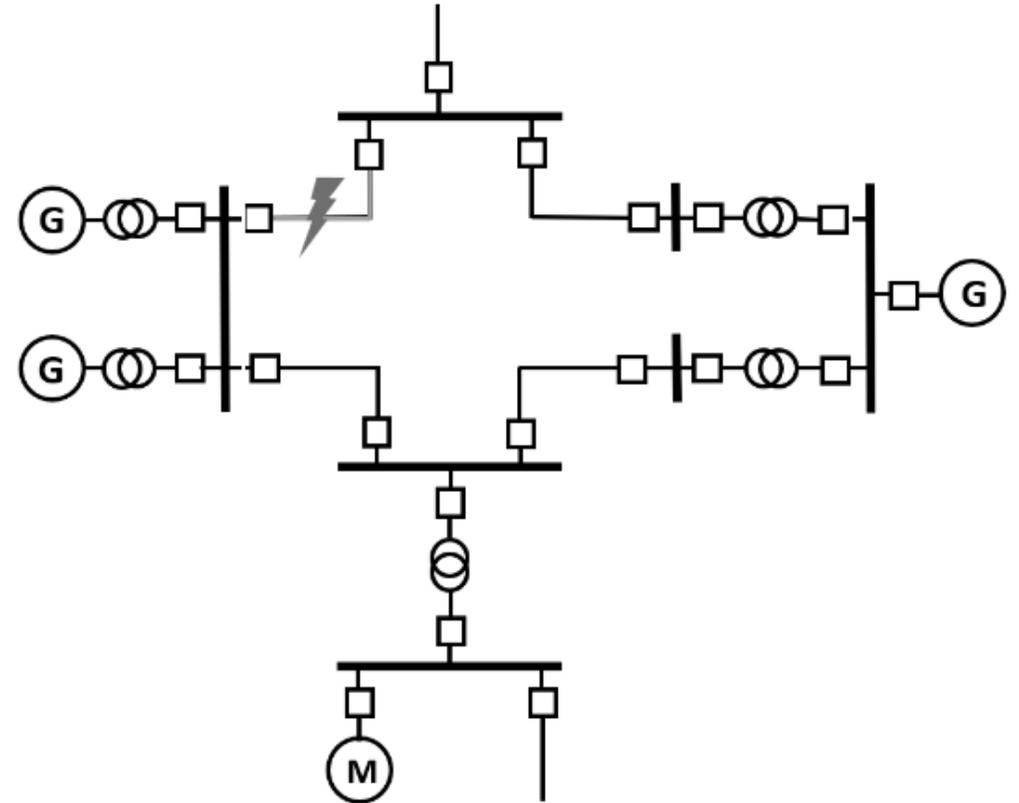
Key terminology

Selectivity

Selectivity is a mandatory requirement for all protection, but the importance of it depends on the application.

For example, unselective protection operation during a medium voltage network fault will cause an outage for an unnecessarily large number of consumers. While this is bad, it's not a complete disaster.

On the other hand, unselective protection operation in the extra high voltage network – i.e. at the national grid level- may endanger the stability of the whole power system, possibly leading to a country – wide blackout.



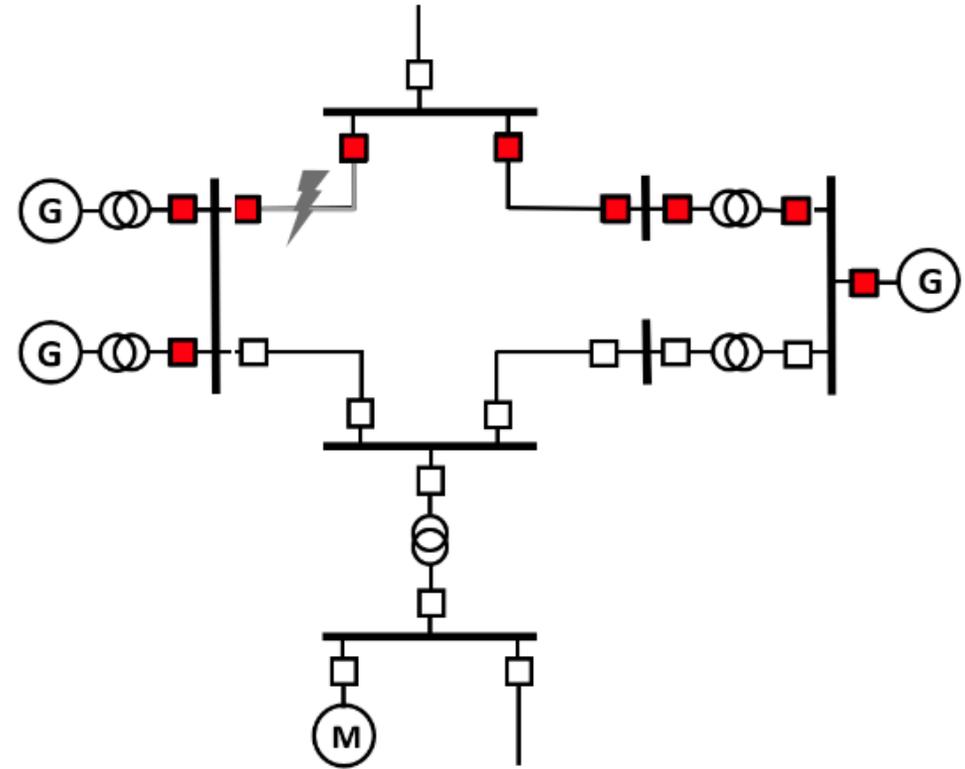
Key terminology

Selectivity – Unselective

Here, Several circuit breakers in the fault current paths from the generators to the fault location have been tripped.

Note that all generators- the power sources – have been disconnected. Therefore, the whole system has gone down, even though many circuit breakers have remained closed.

So, the outage affects all the customers unnecessarily.

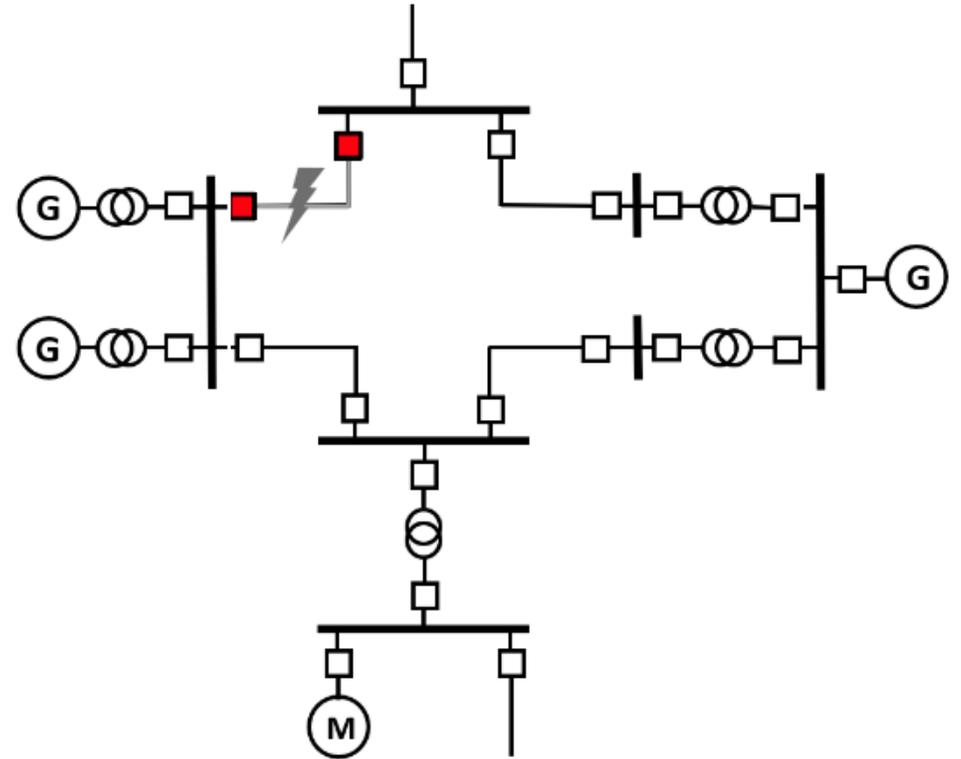


Key terminology

Selectivity – Selective

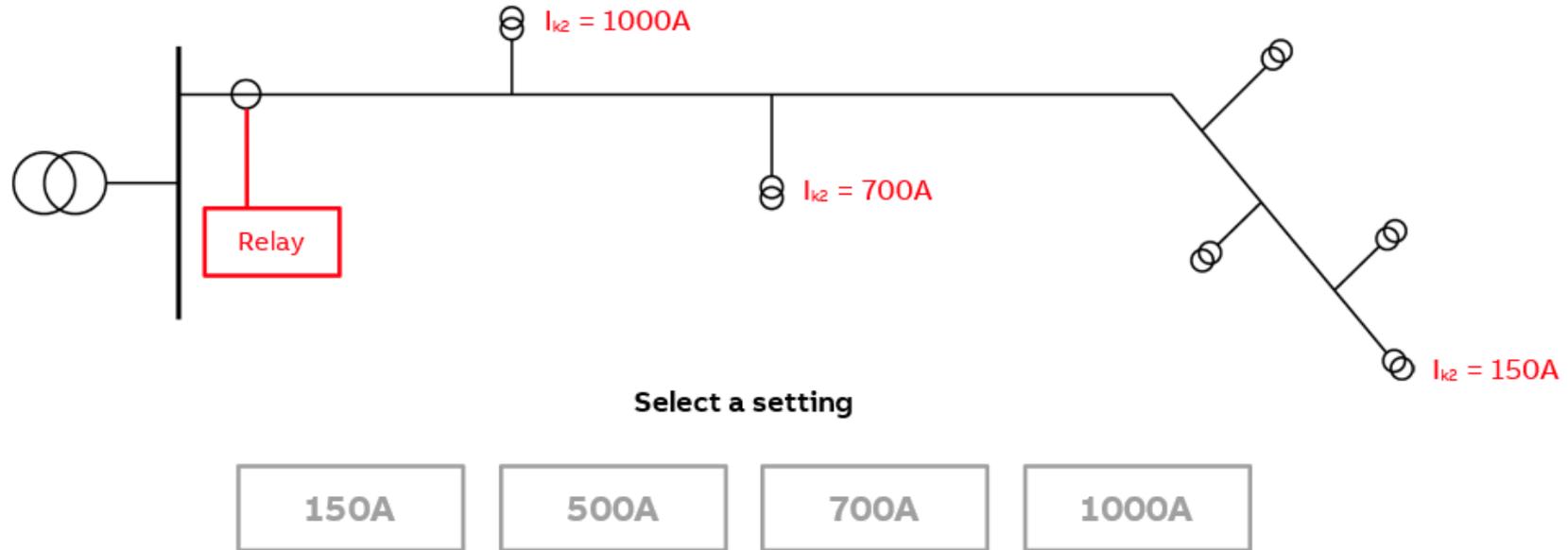
Here, only the circuit breakers closest to the fault have tripped and that means that the fault has been isolated.

Therefore, the outage has been minimized to just the part of the system where the fault occurred.



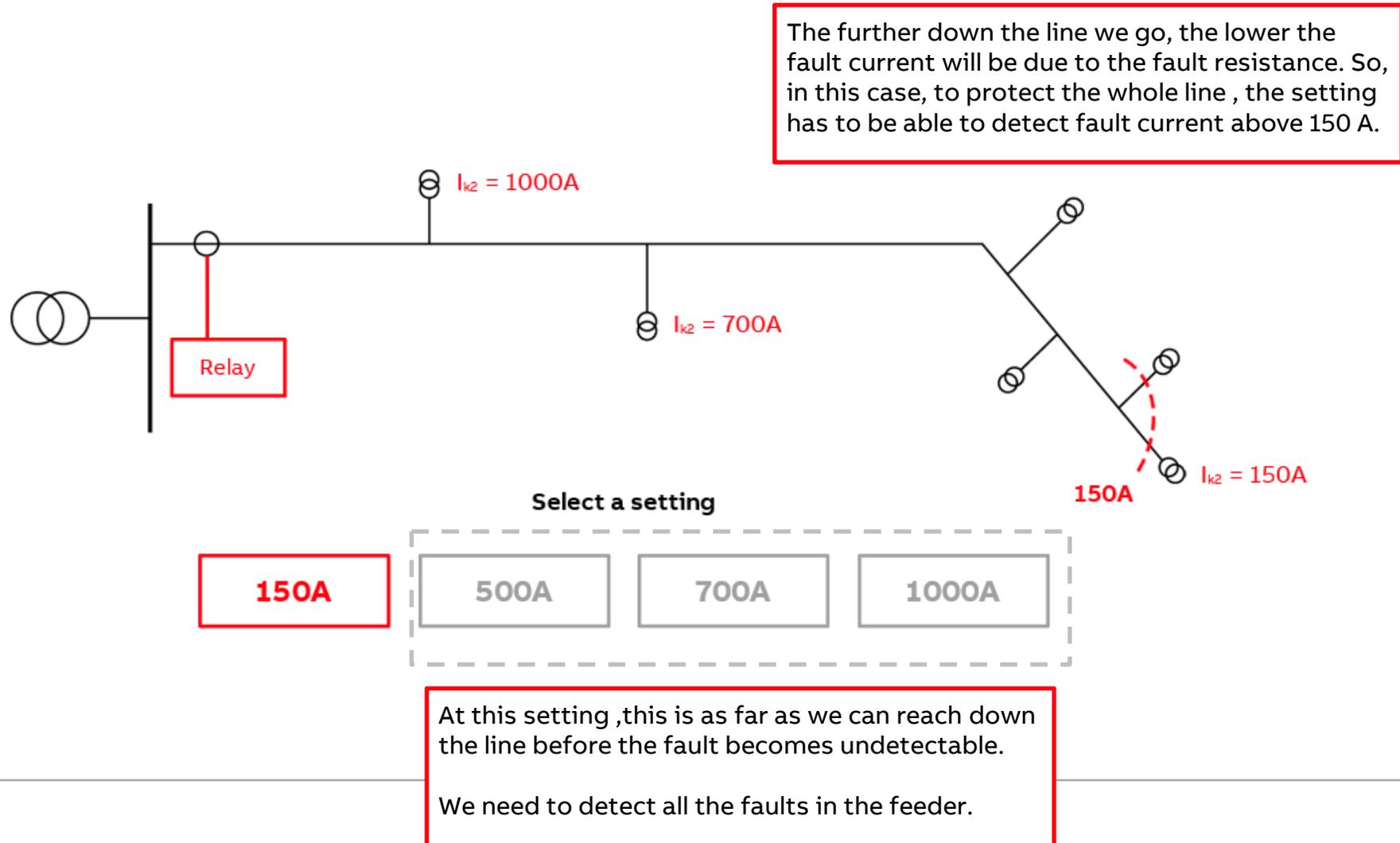
Key terminology

Sensitivity



Key terminology

Sensitivity



Key terminology

Stability

STABILITY OF POWER SYSTEM

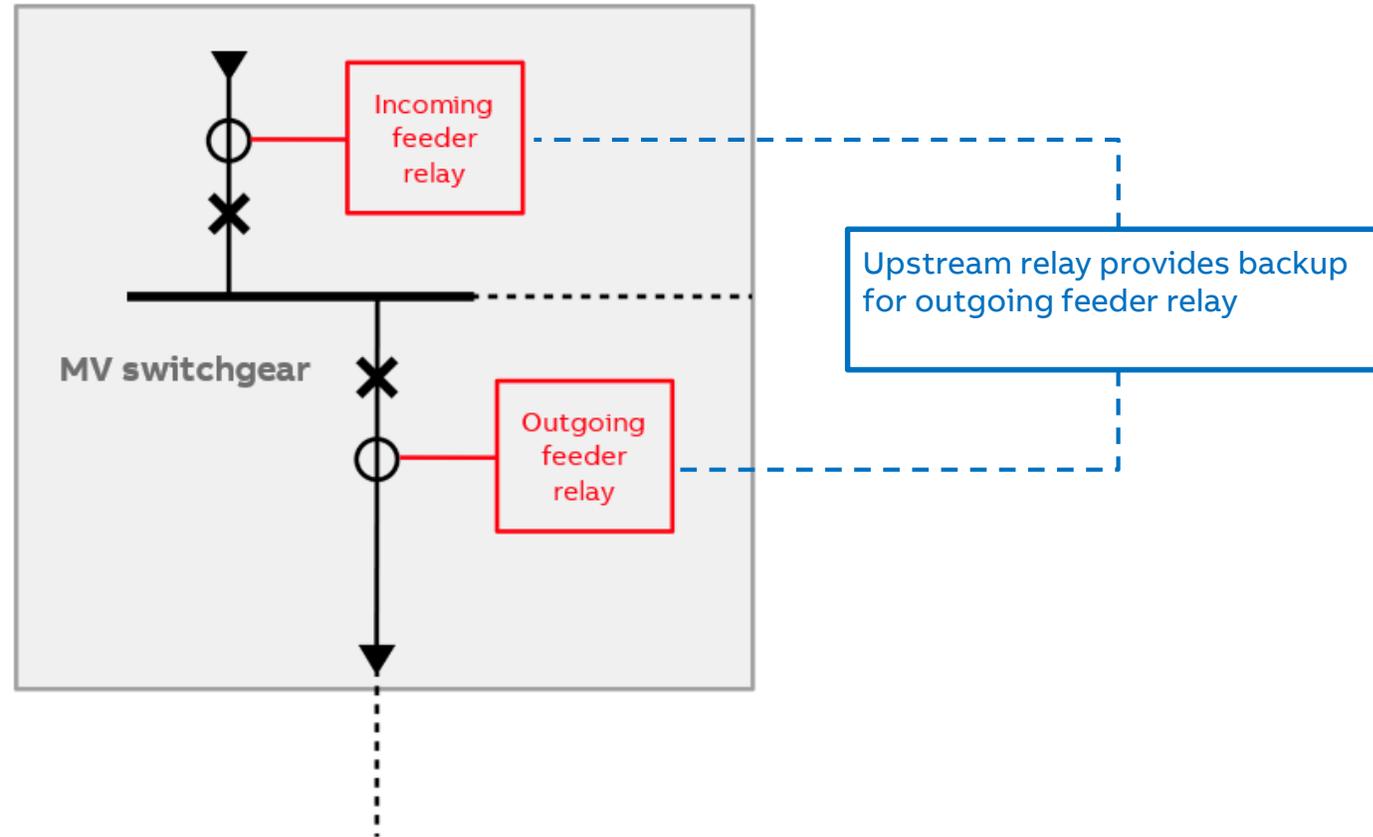
- Power system stability is mostly ability of all generators in the system to run in synchronism with each other
- Power system stability means also ability to maintain acceptable voltage.
- Stability may be lost due to too long clearing time of faults (too long operate times of protection)
- Problem with selectivity can also cause a loss of stability due to loss of too many transmission paths.
- The components used in the power system are usually dimensioned to withstand a short circuit current for one or three seconds but power system stability during short circuit current may be endangered already after 200ms .
- So, protection has to be able to clear the faults in less than 200ms, including CB opening time

STABILITY OF POTECTION

- A protection scheme – for example , a differential protection scheme – is stable when it does not operate on the fault outside of its protected zone .
- So, stability of protection is closely related of security.

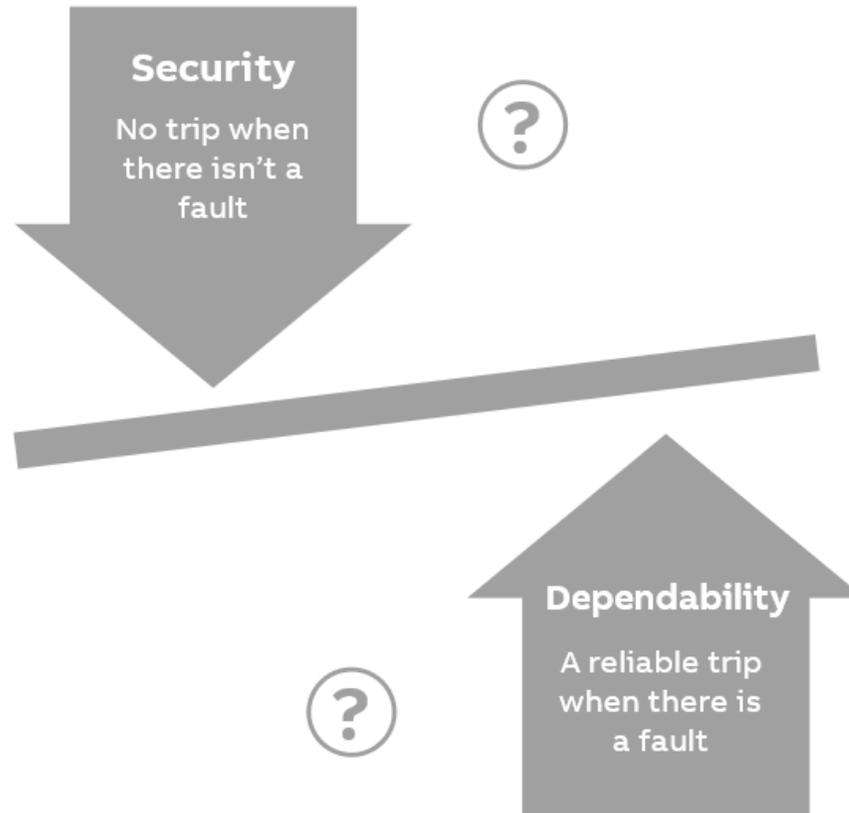
Key terminology

Back-up protection



Key terminology

Dependability and security

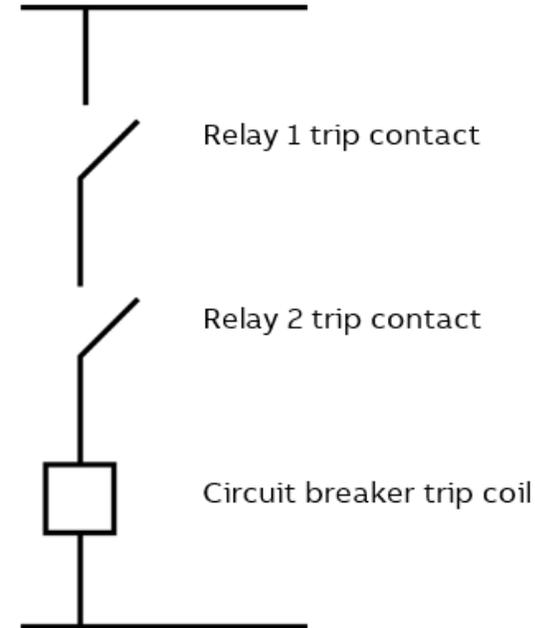


Key terminology

Security

How to increase security

- It may be necessary to increase the security of protection in case of critical loads. Such cases arise when false operation of protection can cause severe damage or high economic loss.
- Security is increased by having two relays in series.
The circuit breaker is tripped **only if both 1 AND 2 operate**.
- Security may also be increased for parts of the protection system. For example, the 2-out-of-3 logic for PT 100 sensors for the thermal protection of motors. The idea is that in a real over-temperature situation the fault is seen by more than just one sensor. If only a single sensor indicates high temperature, it is probably a false indication.
- Modern microprocessor based relays have a comprehensive self-supervision system. Self-supervision will give an alarm and disable tripping if it detects an internal fault in the relay. Then the operating personnel can replace the relay. Therefore, nowadays, increased security by two relays in series is actually a very rare solution.



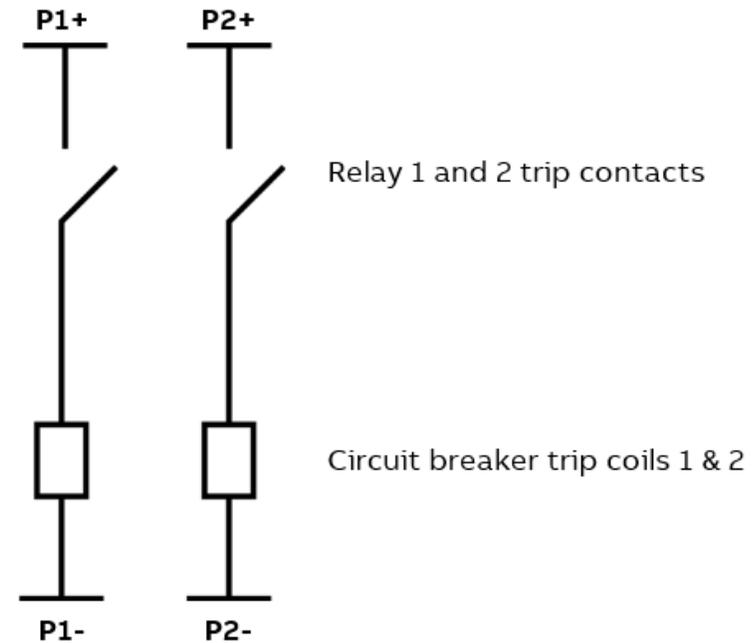
An example of increased security
Connection *in series*

Key terminology

Dependability

How to increase dependability

- DUPLICATION OF PROTECTION
- Dependability is increased by using two relays in parallel so that if either or both operate the circuit breaker is opened.
- In the diagram we see main1 — main 2 protection, which means that both will operate simultaneously.



An example of main 1 – main 2 protection
working *in parallel*

Key terminology

Protected zone

Key point

A protected zone is the part of the network in which faults cause the protection function to operate.

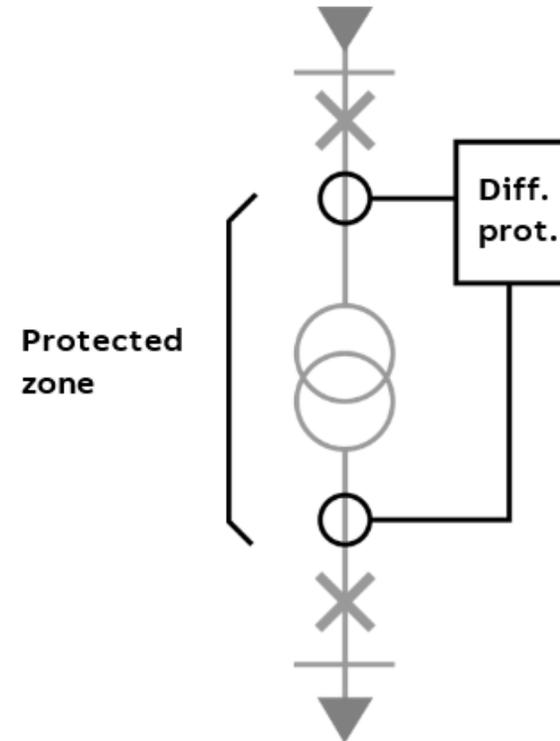


Key terminology

Protected zone – differential protection

- Only differential protection has an precisely defined protected zone.
- It lies in between the current transformers.
- This brings one of the benefits of differential protection — the absolute selectivity.

Protected zone, differential protection



Key terminology

Protected zone – distance protection

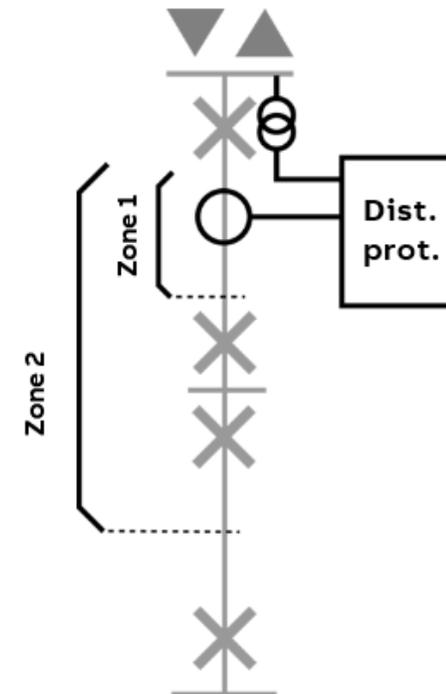
- For distance protection, the zone *reach* is limited by the fault loop impedance.
- The protected zone starts at the local current transformers, but the **far end of the zone is not exact**. It depends on the measurement accuracy and correctness of the data about the impedance values of the protected line.



Reach

- With overcurrent protection and distance protection, the term *reach* is also used.
- *Reach* defines **how far the protection zone extends** — i.e. the length of the protected zone.
- Reach can be defined in impedances (ohms), but also as physical distance (km, miles) when the protected object is a power line.

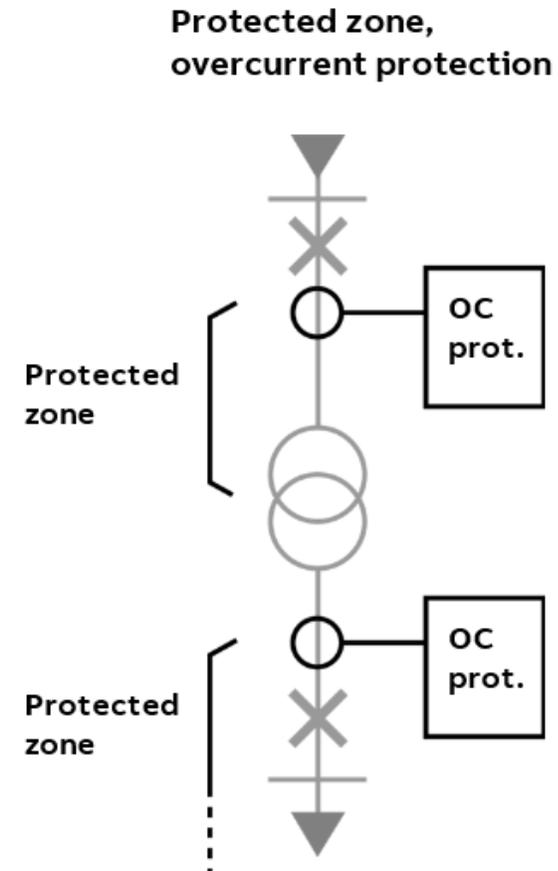
Protected zone, distance protection



Key terminology

Protected zone – overcurrent protection

- For overcurrent protection the zone is **limited by the fault current magnitude**.
- For overcurrent protection, the zone reach is even more blurred. It depends on the magnitude of the fault current, which depends on the source short-circuit power. The reach **is not defined by the protected object itself**.
- Moreover, the fault current magnitude depends on **fault resistance** and **how many phases** are involved in the fault.
- In the diagram, the high-set overcurrent is set so that it operates only on faults on the high voltage side of the transformer. This is possible because the transformer is a significant current limiting impedance, and therefore the difference in the fault current magnitude is large between faults on the high and low voltage sides of the transformer.



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Time coordination and grading

Time coordination and grading

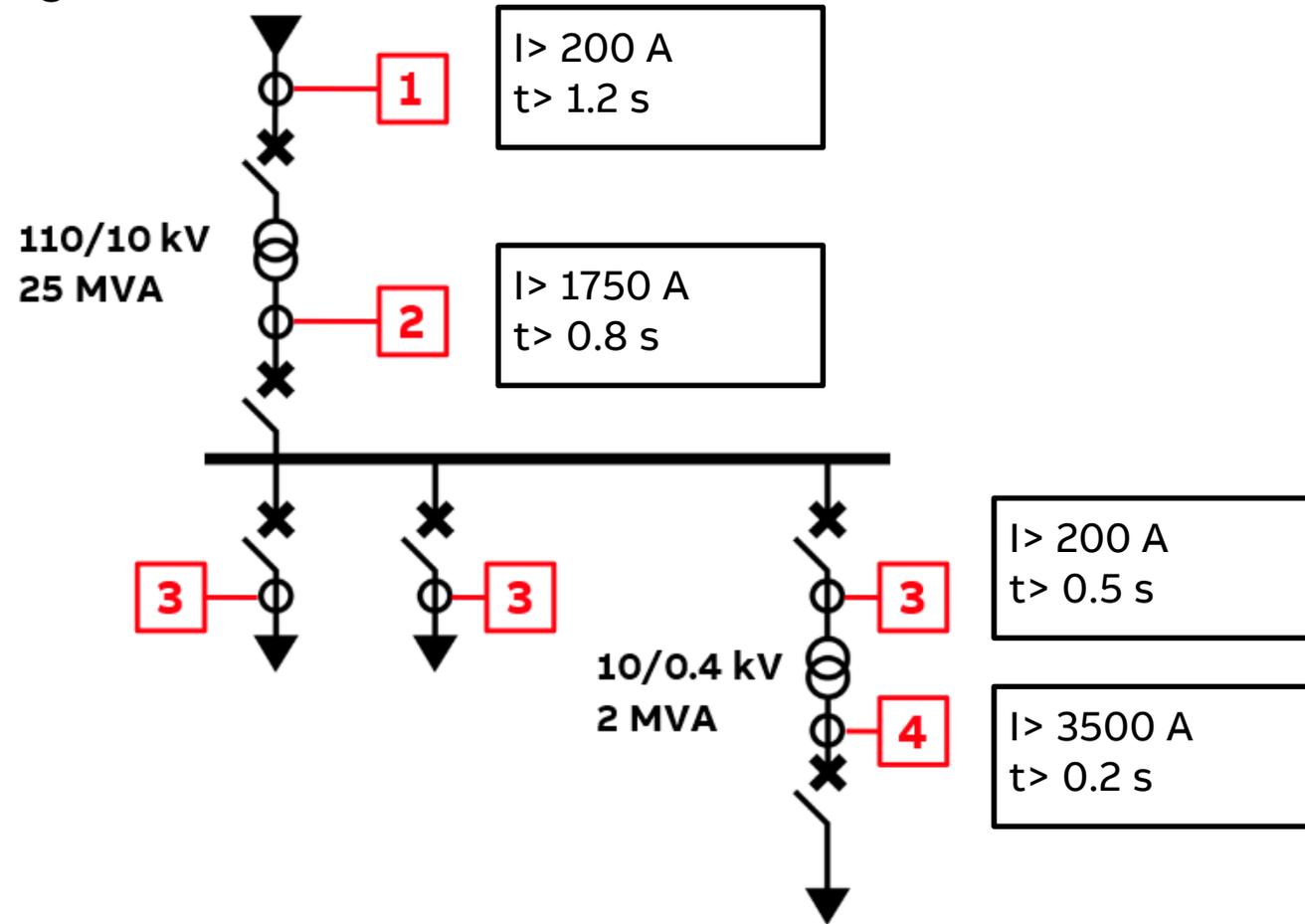
Time coordination and Time grading

$I > 200 \text{ A}$
 $t > 1.2 \text{ s}$

$I > 1750 \text{ A}$
 $t > 0.8 \text{ s}$

$I > 200 \text{ A}$
 $t > 0.5 \text{ s}$

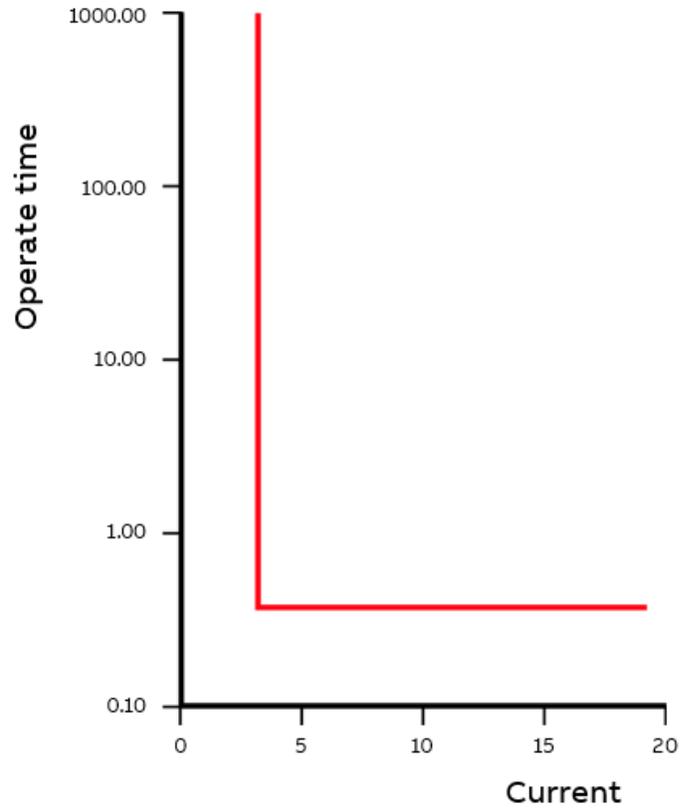
$I > 3500 \text{ A}$
 $t > 0.2 \text{ s}$



Time coordination and grading

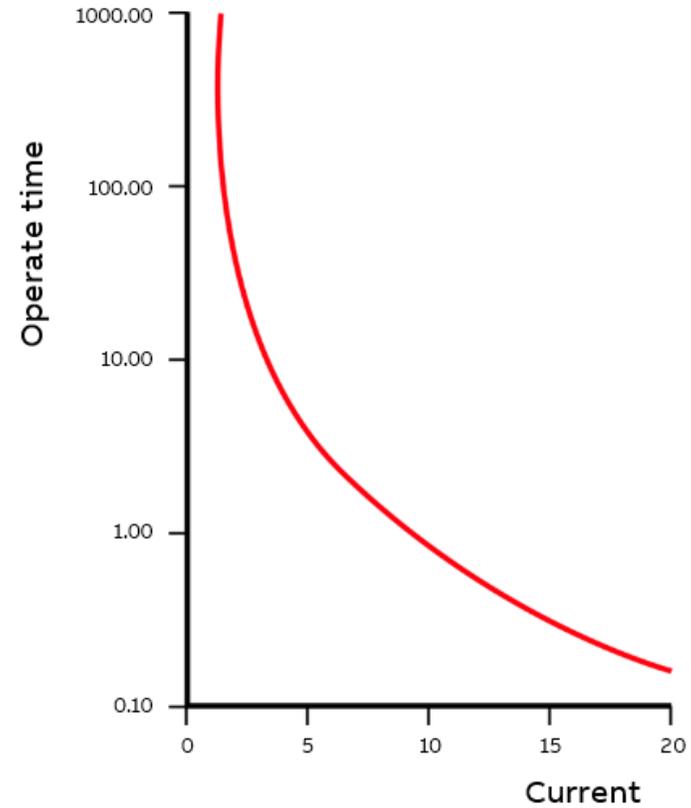
Time delays

Definite time



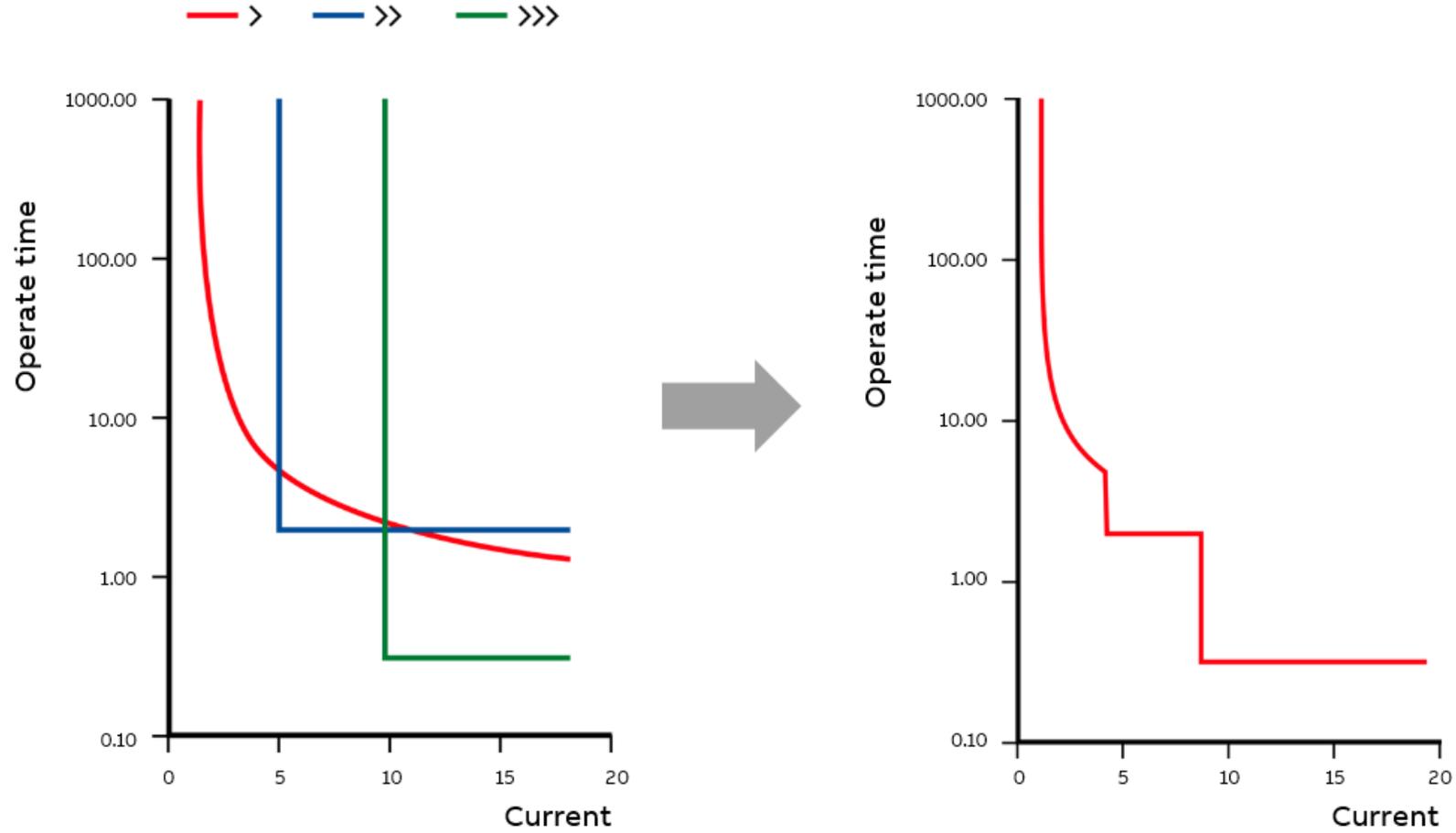
VS.

Inverse time



Time coordination and grading

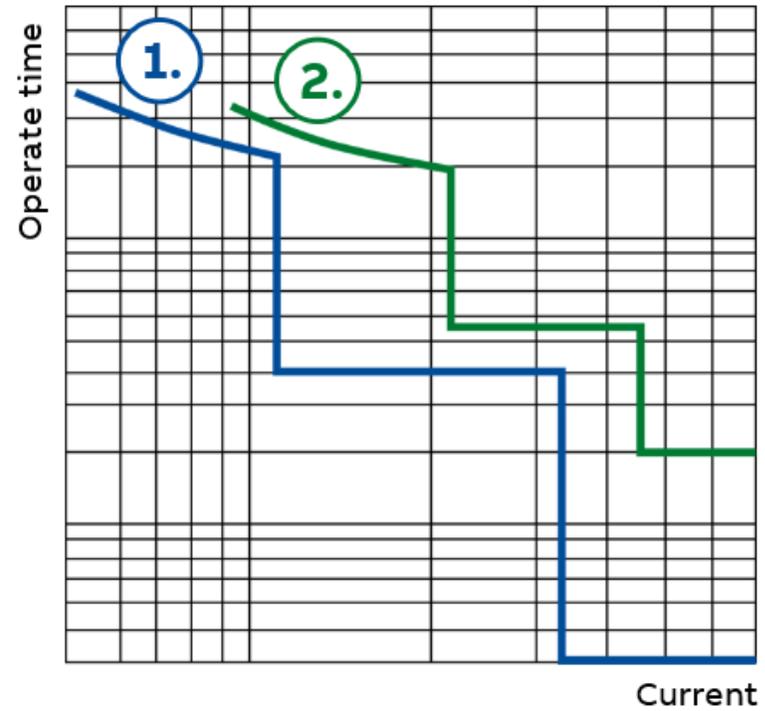
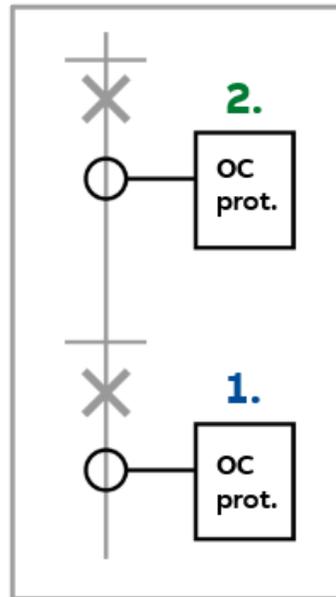
Time delays



Time coordination and grading

Coordination and grading

Coordination between upstream and downstream relays with overcurrent protection.



Take aways

- Protection is needed to detect electrical faults and abnormal operating conditions.
- Protection is also needed for protecting people and property around the power network.
- When taking about protection
 - Selectivity means that the minimum part of the network is de-energized
 - Sensitivity means that all the faults are detected
 - Dependability means that a real fault will trip the protection
 - Security means that a false fault will not trip the protection
- The protected zone is the part of the network in which faults cause the protection function to operate
- The protected zone is defined and limited by different things depending on the protection function.
- Definite time delay means that the protection operate time dose not change or depend on the fault type or the fault current magnitude.
- Inverse time delay, on the other hand, depends on the current magnitude so, the higher the current, the shorter the delay.



Types of faults

Protected objects

Power lines

Transformers

Generators

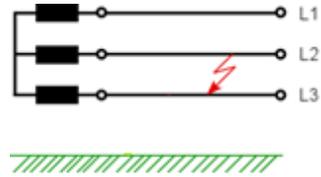
Motors

Capacitor
banks

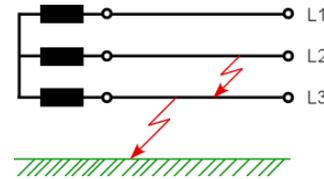
Busbars

Power
systems

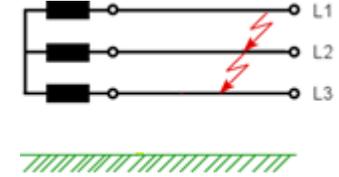
Power lines (overhead lines and underground cables)



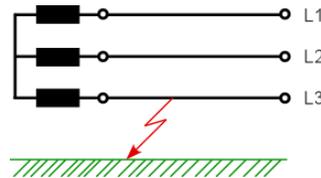
Two-phase short circuit



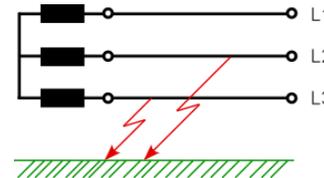
Two-phase-to-earth fault



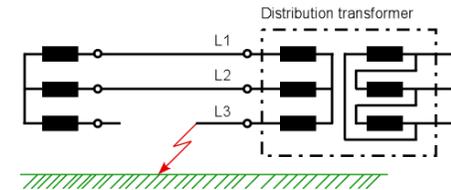
Three-phase short circuit



Earth fault

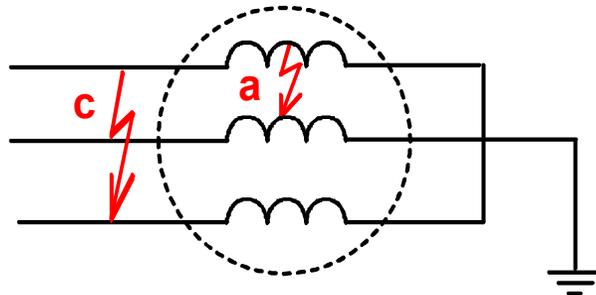
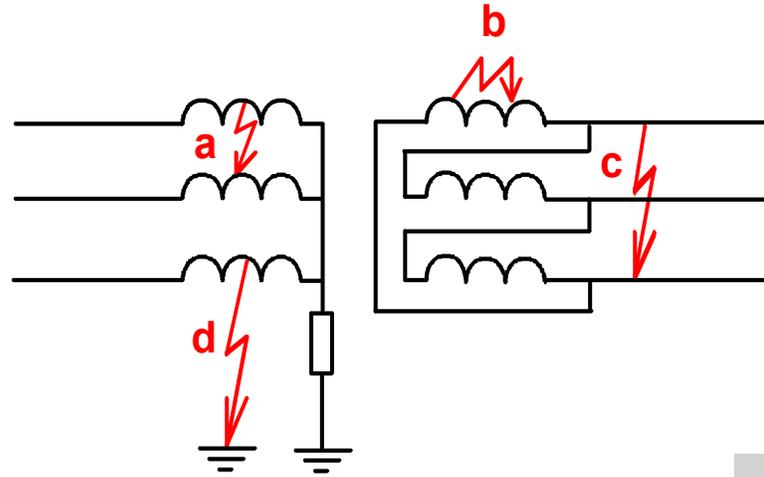


A double earth fault
(Cross-country earth-fault)



Broken conductor and
an earth-fault

Transformers



Other faults that can occur are:

- Over-excitation
- Overload

Short circuits

Interturn fault

Earth fault

Other

Generator

Typical fault types

Stator

- Interturn faults (1)
- Short circuits (2)
- Earth faults (3)
- Hot-spots (4)

Rotor & excitation

- Earth faults and interturn faults (5)
- Over- and under-excitation (6)

Prime mover

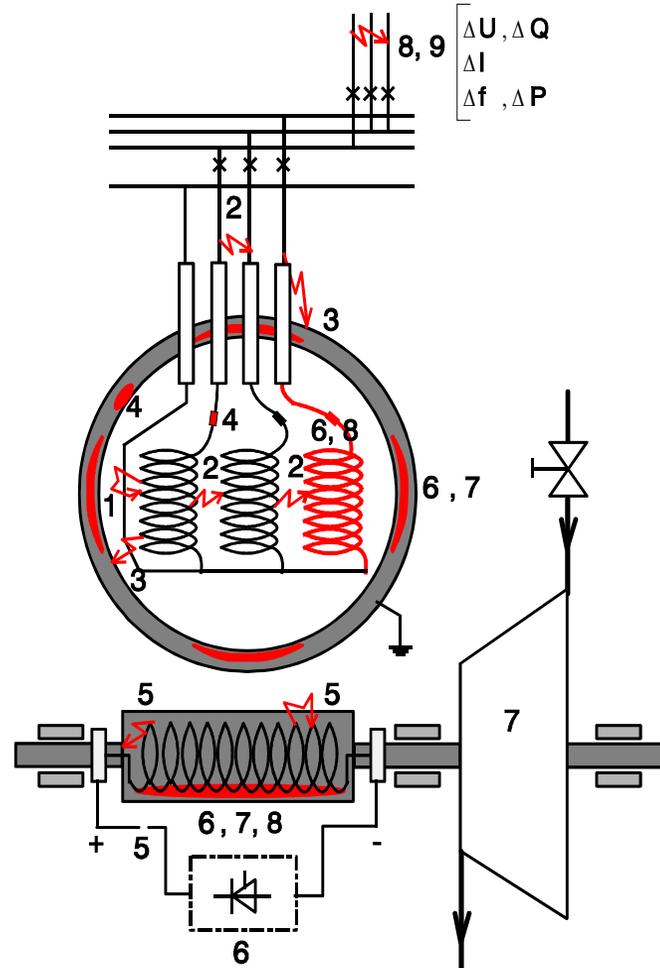
- Reverse power (7)
- Jamming (7)

External network

- Short circuits (8)
- Earth faults (9)

Other external network faults

- Unbalanced load
- Overload
- Under- or over-voltage
- Under- or over-frequency
- Disconnection of load or generators



Motors



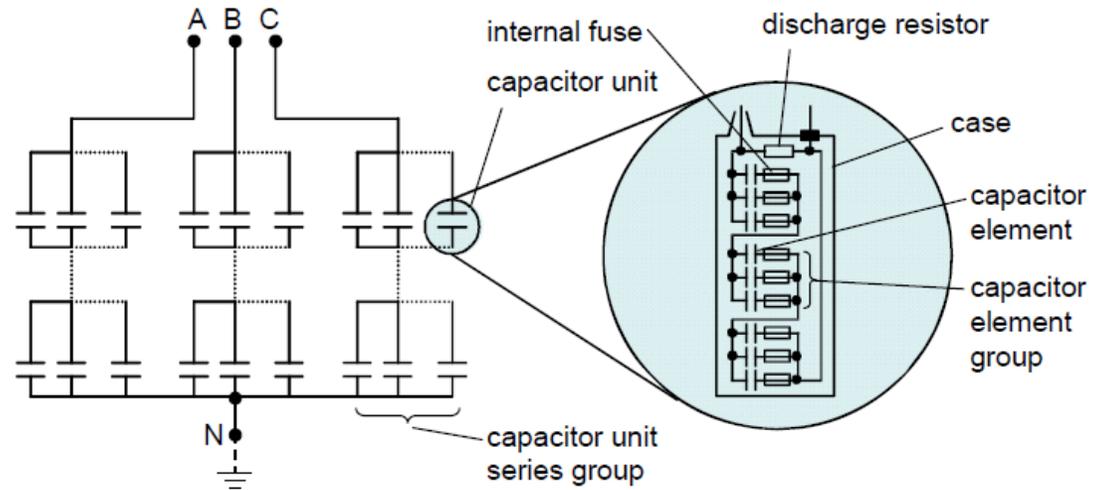
INTERNAL FAULTS

- Short circuits
- Interturn faults
- Earth faults
- Hot-spots
- Bearing damages
- Over- and under-excitation (Synchronous machines only)

EXTERNAL FAULTS

- Jamming
- Overloading, insufficient cooling
- Start-up stress, reversed sequence starting
- Supply voltage unbalance or single phasing
- Over- and under-voltage
- Vibration

Capacitor banks



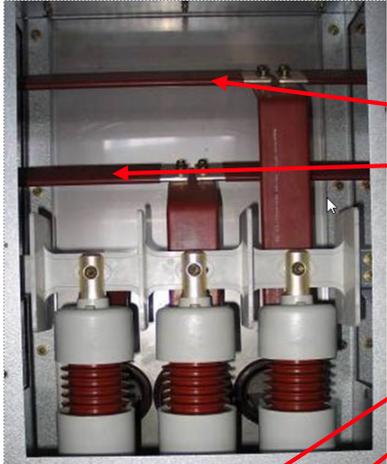
INTERNAL FAULTS

- Short circuits
- Earth faults
- (Single) element failures => unbalance

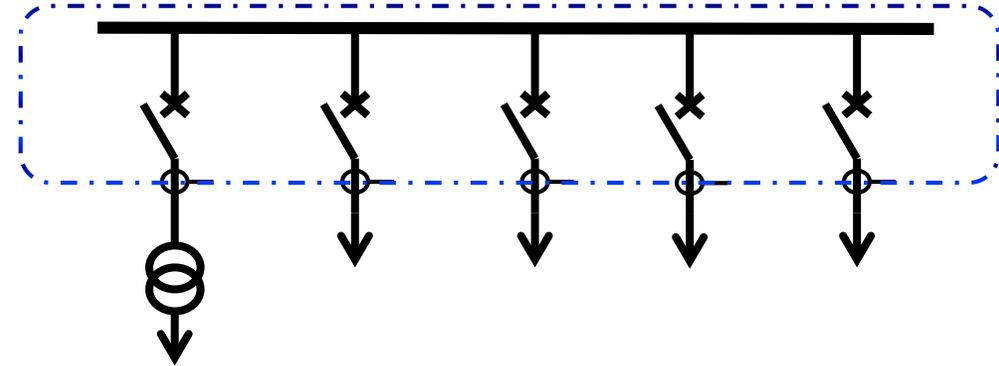
EXTERNAL FAULTS

- Overloading due to over-voltage
- Overloading due to harmonics
- Switching resonance

Busbars



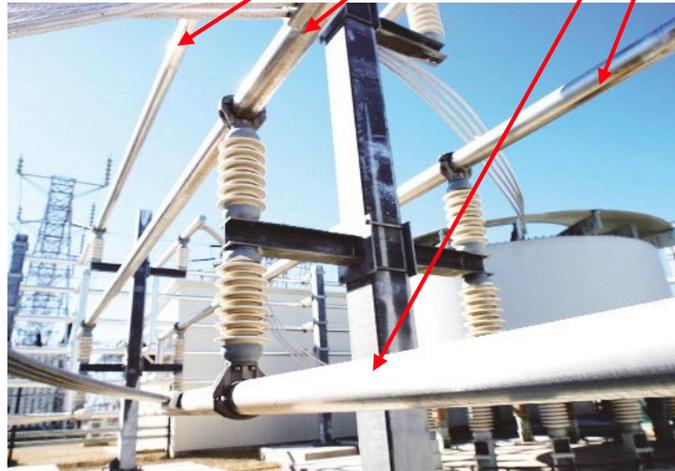
Busbars



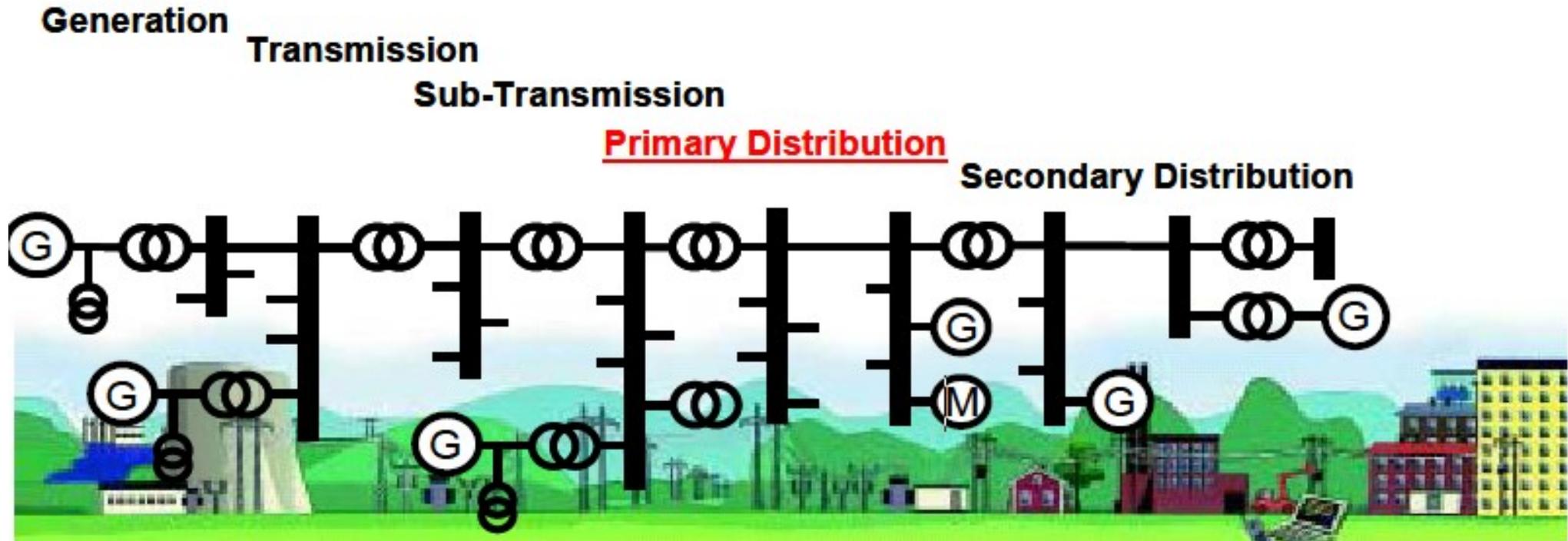
A busbar in a single line diagram and protected zone of busbar differential protection (blue dotted line).

The typical faults are:

- Short circuits (phase-to-phase faults)
- Earth faults (phase-to-earth faults)
- Multiple fault loops (phase-to-phase-to-earth or three phase faults)



Power system



Power system

The typical faults are:

- Load/power generation unbalance => under-/over-frequency
- Reactive power consumption / production unbalance => under-/over-voltage
- Loss of stability of synchronous operation:
 - Fault clearance time
 - Exceeding of transmission capability (not same as overload)
 - Loss of critical transmission paths

ABB protection and solution

ABB Distribution Automation

Portfolio

Relion Range

Basic Range

605 series



611 series



615 series



620 series



Hi-end Range

630 series



640 series



Grid Automation

RER/REC
615 series



RER
620 series



600 family

Station products

SSC600



COM600



RIO600



Arctic



Other solutions and legacy

SW

PCM600
ZEE600
(ABB Zenon
+Envisage)

Tools

FT's &
cables



Solutions

DSC



Legacy

500 series
REA, EM, SACO



Distribution Automation Solution

KPI's example: solutions for Food and Beverage

- 1 Improve energy efficiency**
Power Management System (PMS) for secured power supply to critical loads in the to reduce unplanned downtime for important production areas and to reduce power consumption by planned downtime
- 2 Easy maintenance**
Monitoring system for fast event recognizing allows operators, maintenance staff and production supervisors to prevent or fix effectively downtime issues as they happen, instead of weeks later.
- 3 Power Quality, Protection and Utility connection**
Relion protection and control relays for several application reduce complexity. Long term cost reduction (TCO) for trainings and maintenance by reduce variety of relays
- 4 Power Management**
Monitoring and effective power and energy management environment from medium and low voltage – ensure service continuity and reliability of the network
- 5 People/plant safety**
A fast and selective arc fault mitigation for air-insulated LV & MV switchgear and Relion protection and control relays and sensor technology protect staff and plant facilities for many years.
- 6 Increase OEE**
Various application for automatically transferring supply to a healthy incoming feeder to increase manufacturing time that is truly productive which includes three main factors: availability, performance, quality

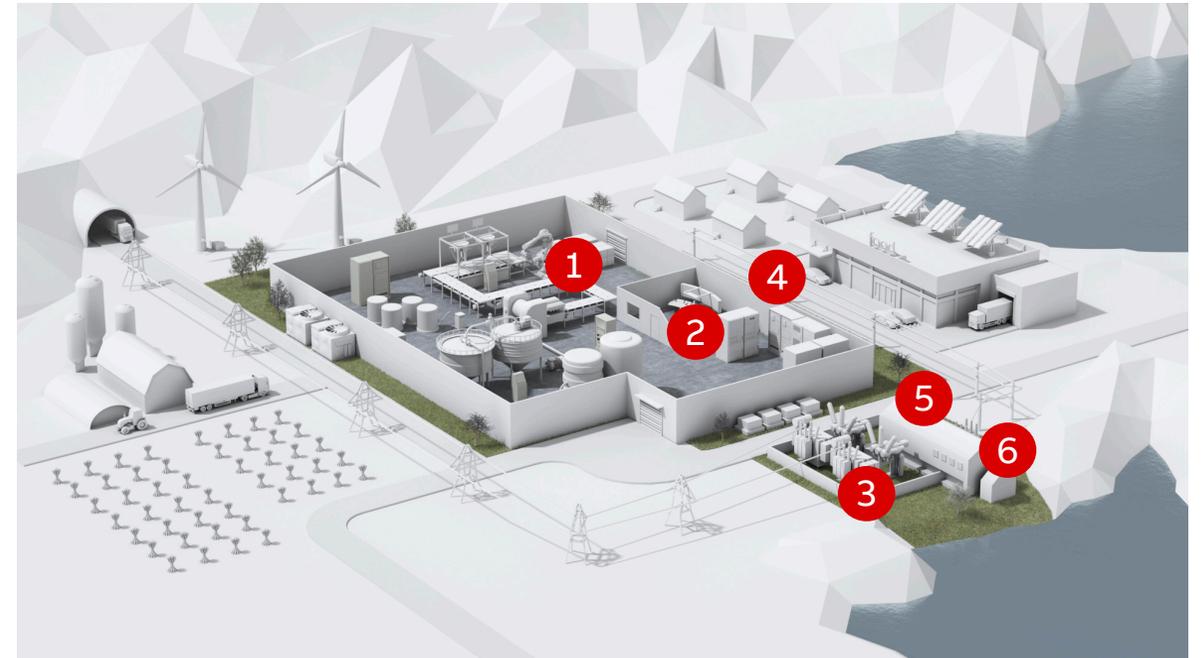
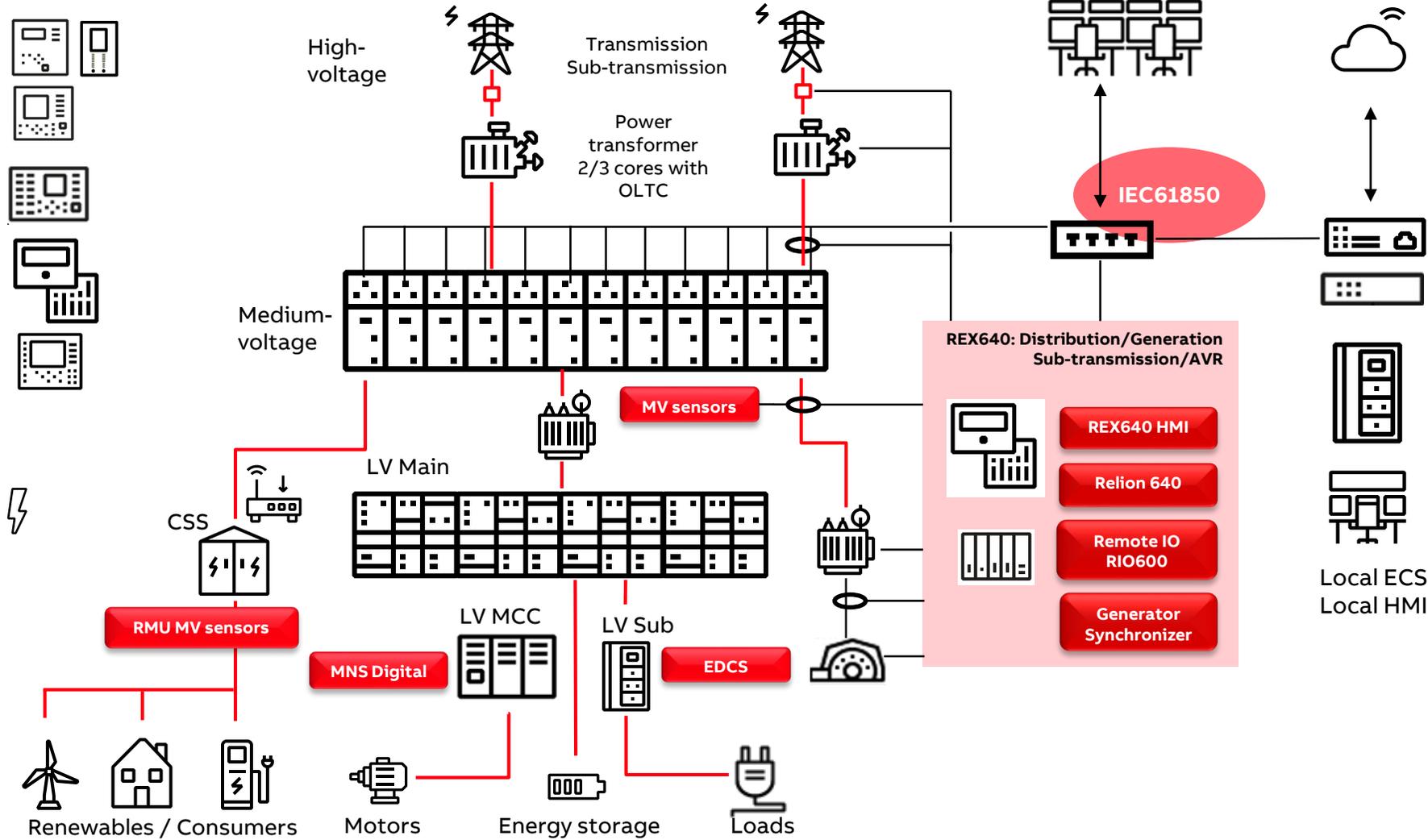


ABB Electrification Digital Solutions

- Protection & control devices**
- Relion 605 series
 - Relion 615 series
 - Relion 620/630
 - Relion 640
 - PML630 Load-shedding controller
 - SSC600

- Distribution automation solutions**
- Arc Flash protection
 - Relay retrofit
 - Fiona w/RTU
 - Smart Control
 - Directional fault location+restoration
 - Communication Public Wireless



- Condition monitoring**
- ABB Ability Condition monitoring

- Local HMI + Tools**
- Engineering IEC61850
 - SSC600 Centralized Protection
 - P&C cabinets
 - PCM600

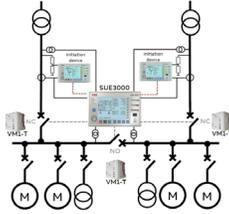
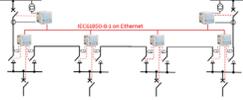
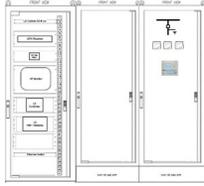
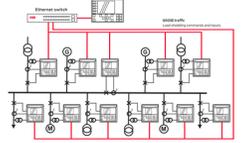
- Electrical Control System**
- ABB Ability COM600
 - ABB Zenon ZEE600
 - ABB Envisage (US)

- Applications**
- compact PMS
 - ATS - Fast transfer switch
 - Loop Control

Cloud-Enabled
ABB Ability Edge Technologies

Digital Solution Centers

Digital Solution Centers offering - Detailed

								
Performances	Engineering Services and IEC61850 logics/templates	REA arc detector + UFES - extinguishing time of < 4 ms	SUE3000 with fast breakers VM1-T < 10 ms				Full PMS systems including 800xA/Zenon up to 6 generators	
	Trainings, Certifications and support	REA arc detector + breaker trip - extinguishing time of < 60 ms	SUE3000 and conventional breakers < 100 ms	FDIR solutions, Zone concept and LC1000 (Loop control)	Pre-configured automation cabinets for HMI/Gateway applications	COM600 with ABB Zenon Energy Edition	+ Generator synchronisation, Transformer control, Load-sharing, Power control	
	Pre-configured matching units and RRP + customized solutions	Arc detection in Relion series + trip breaker - extinguishing time of < 65 ms	Arctic GPRS/LTE devices with configuration + M2M server gateway system	Transfer switch with IEC61850, Goose < 500 ms	Grid automation boxes packages, FIONA	Pre-configured protection panels and cabinets	COM600 with COM600 software	Supervision, control and Load shedding cPMS
	Services	Arc fault protection	Communication	Transfer switch	Grid Automation	Control and Relay cabinet	ECS Electrical Control System	PMS Power Management System

Note: majority of Distribution Automation Solutions and Success stories do combine different solutions, based on customer need's and KPI's

ABB on social media

Website: www.abb.co.th



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Line official: @askabb



ABB