

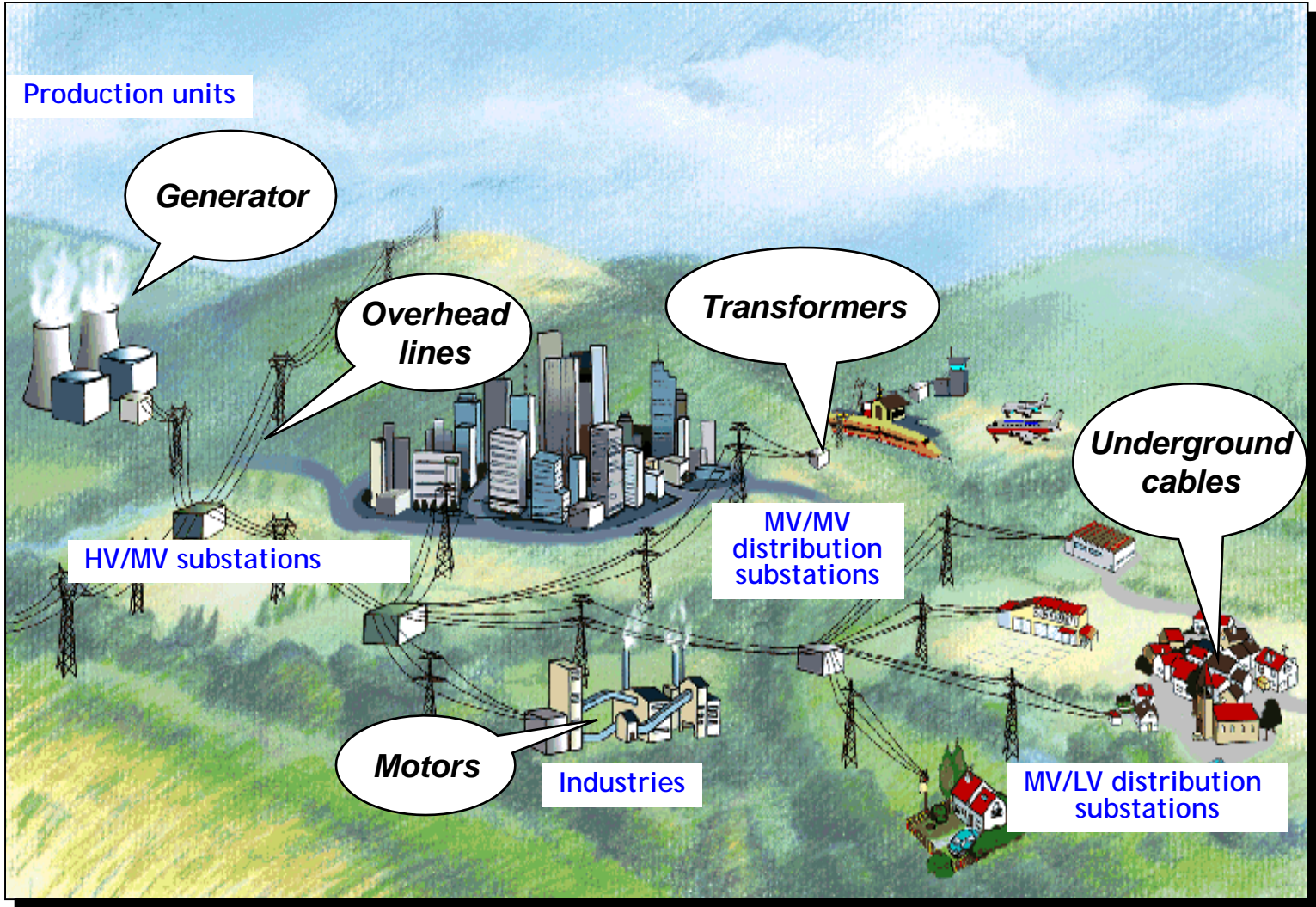
# MV Network Switchgear, Protection and Control

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Schneider Electric, New Delhi.

# Agenda

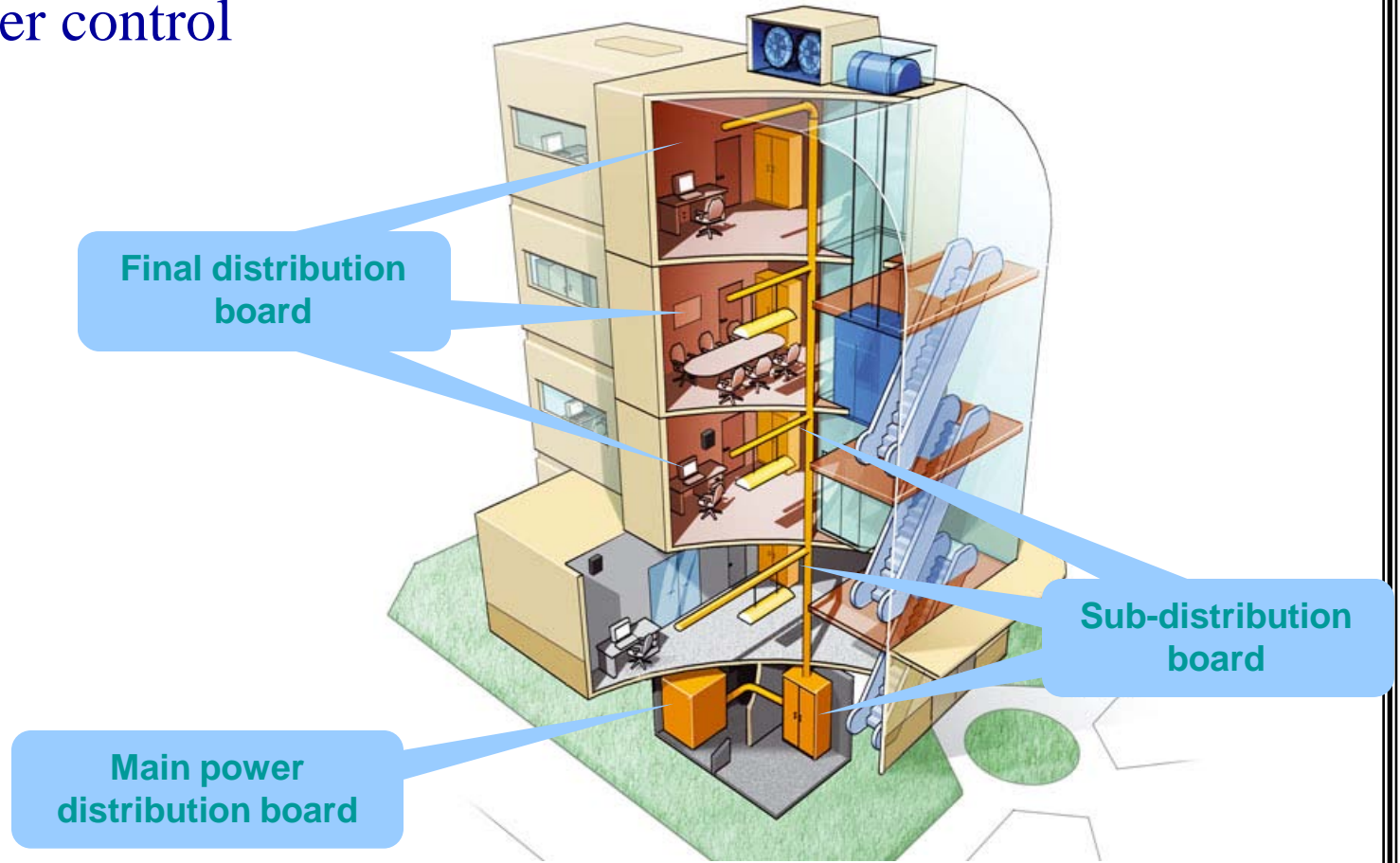
- An Overview
- MV Network
- Basic Definitions
  - Circuit breaker
  - Switchgear
  - Control gear
  - Fault
- Basic functions
  - Disconnection
  - Control
  - Protection
- Protection Index
- Faults
- Arc breaking techniques
- Discrimination
- Current limitation
- Cascading
- IEC 60 947
- LV Control

# Overview

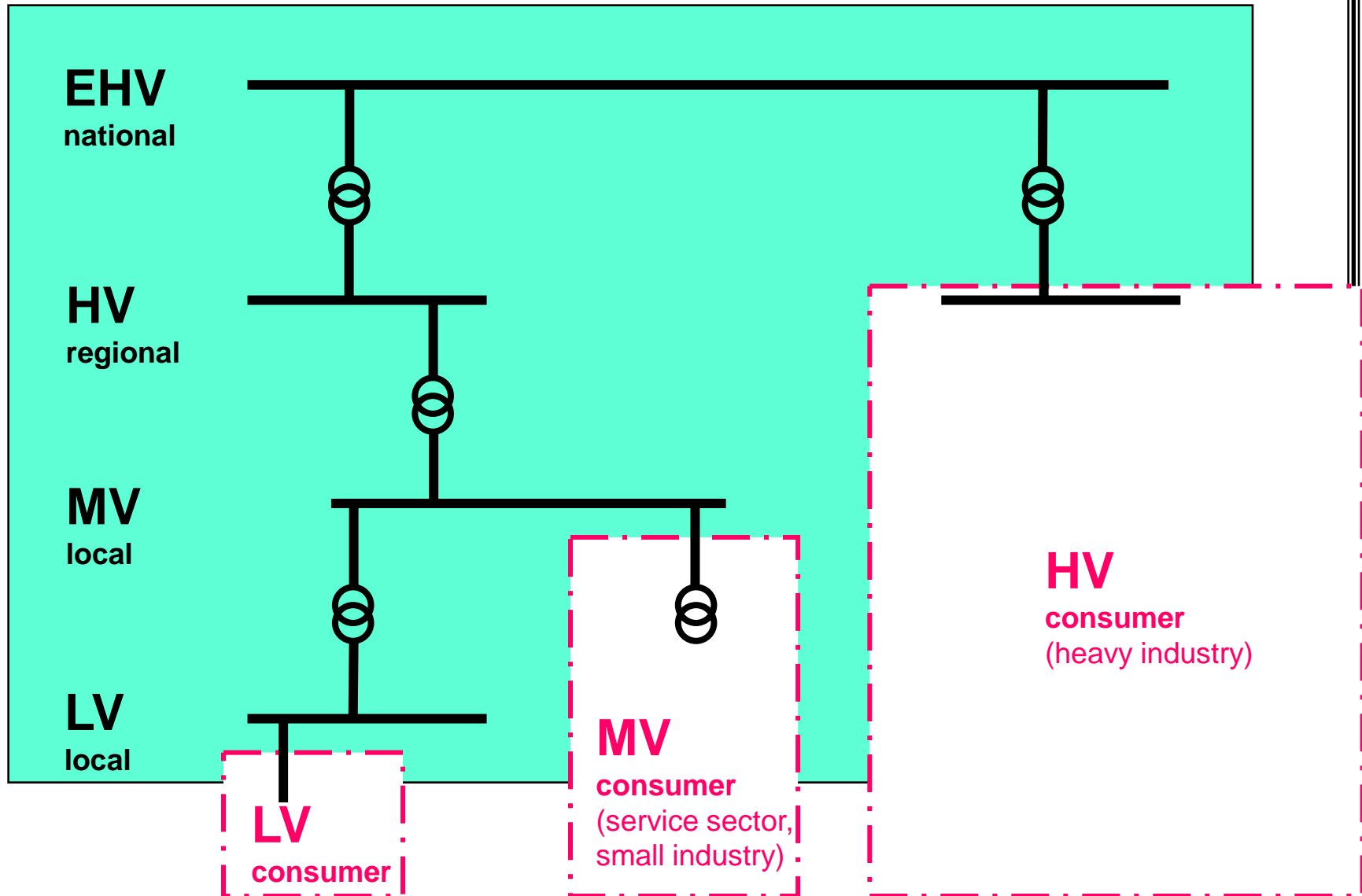


# Overview

## □ LV power control

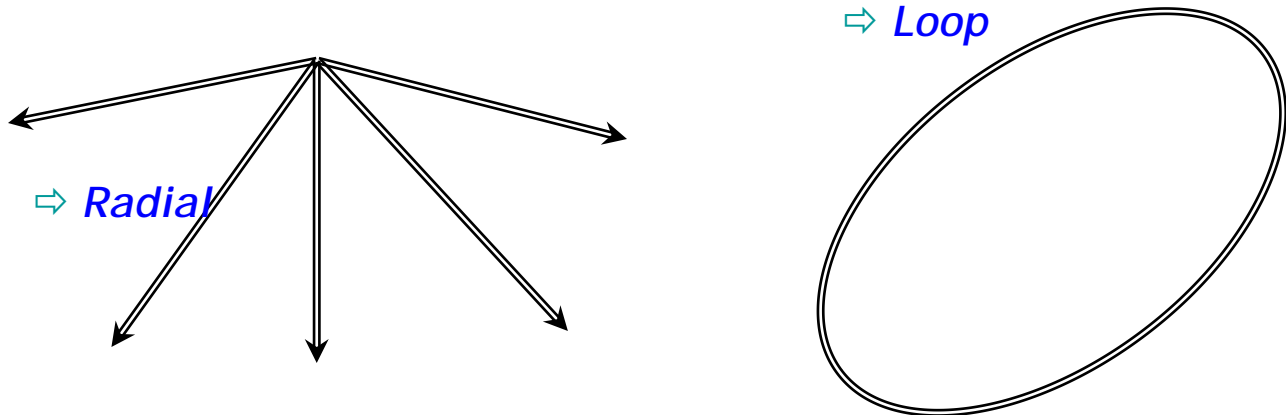


# Public Network

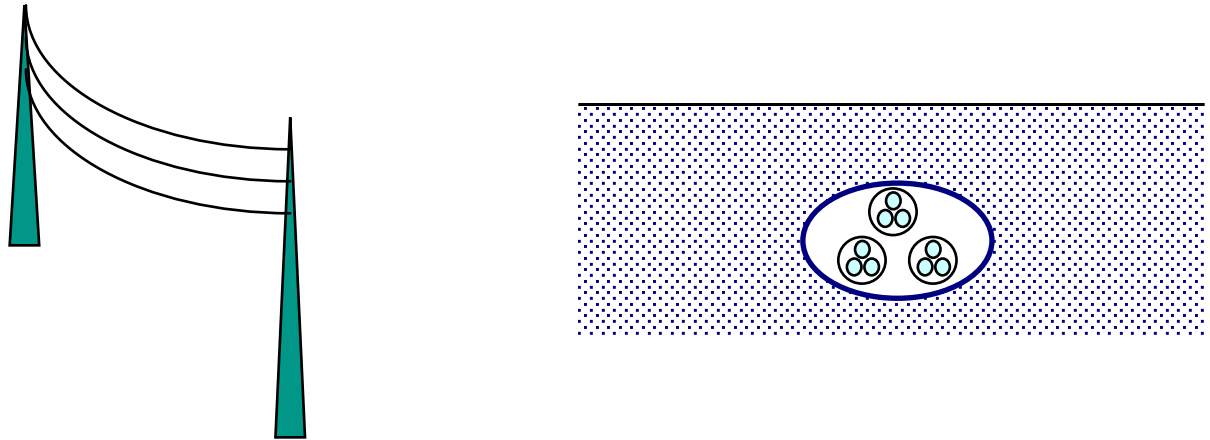


# Different types of MV networks

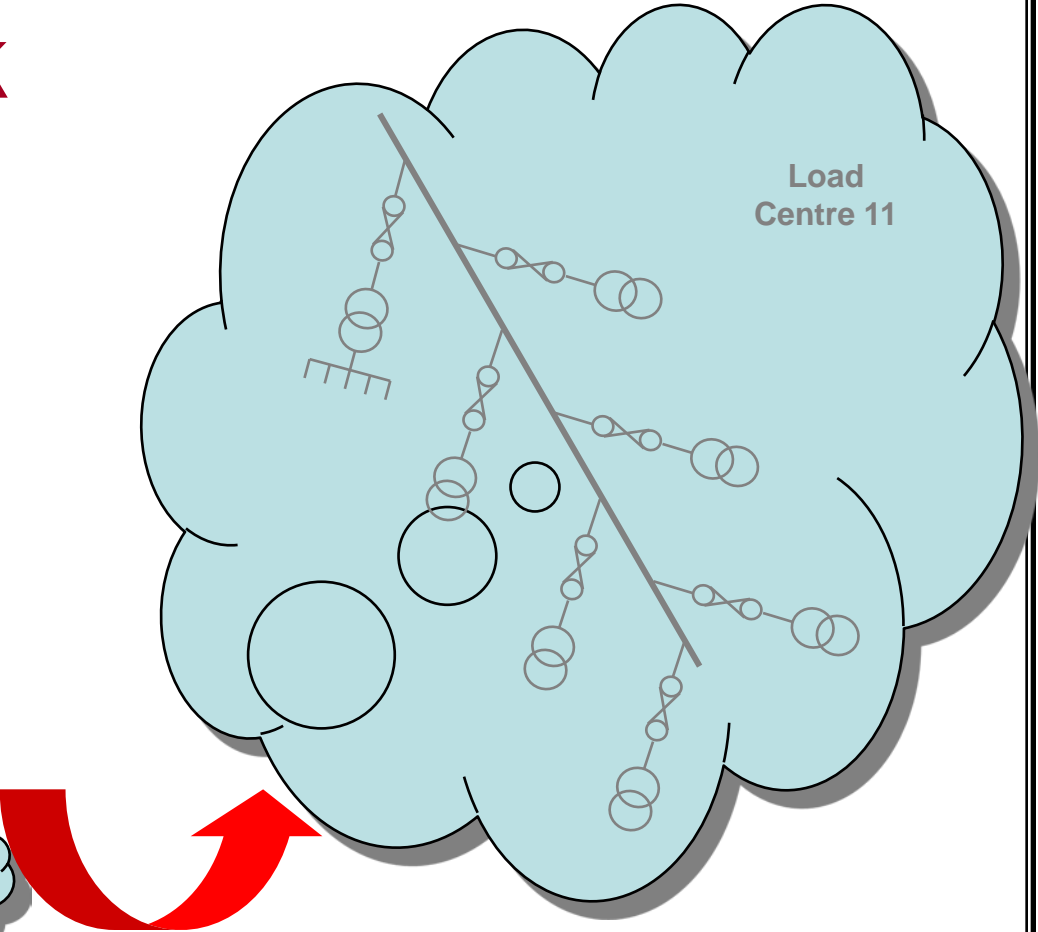
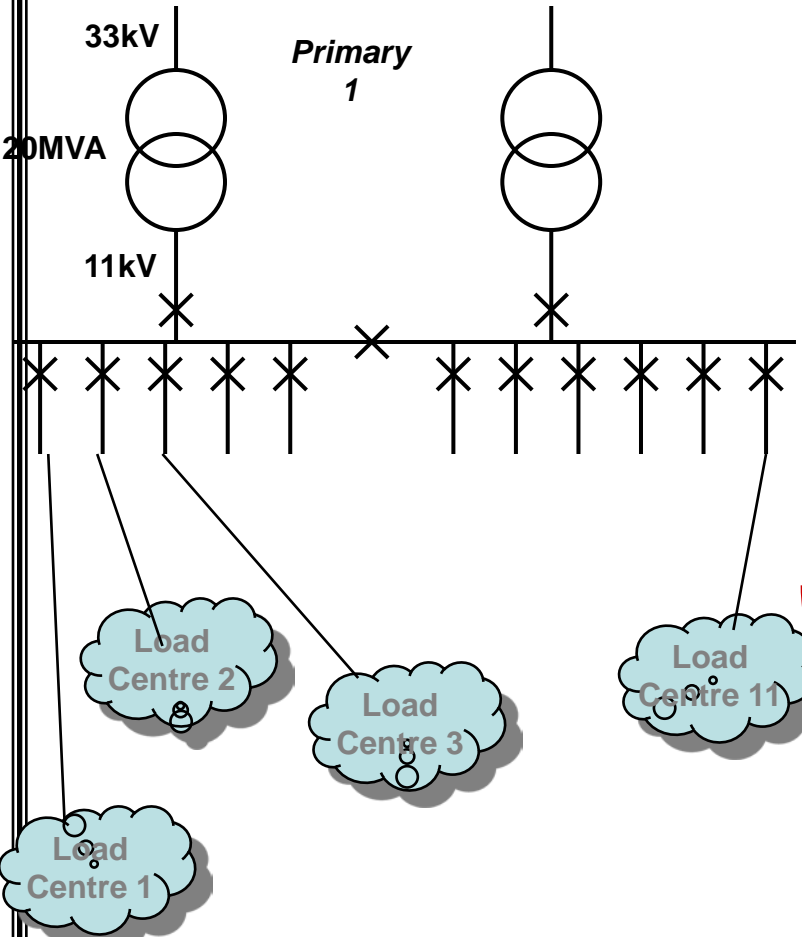
□ Two types of configuration



□ It can be either Overhead or underground



# Radial network



# Radial network

❑ Suited to applications where load is quite widely distributed throughout site

■ Used mainly for LV distribution

## ❑ *ADVANTAGES*

■ Simplest system configuration

■ Easy to protect with time graded overcurrent

## *DISADVANTAGES*

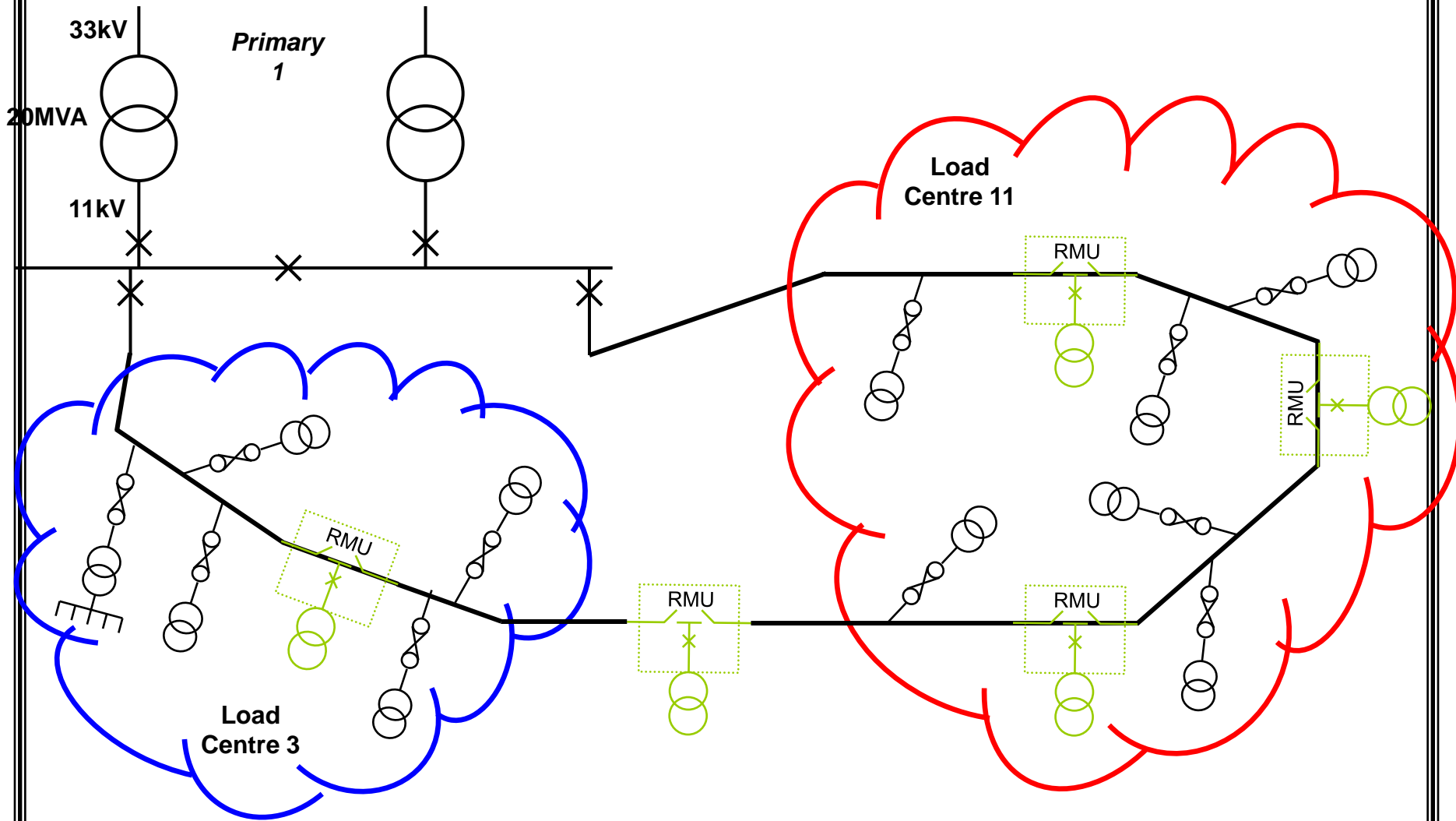
■ Occurrence of a single fault will result in complete loss of supply to the load centre

■ Supply cannot be restored until fault is repaired - long disconnection times

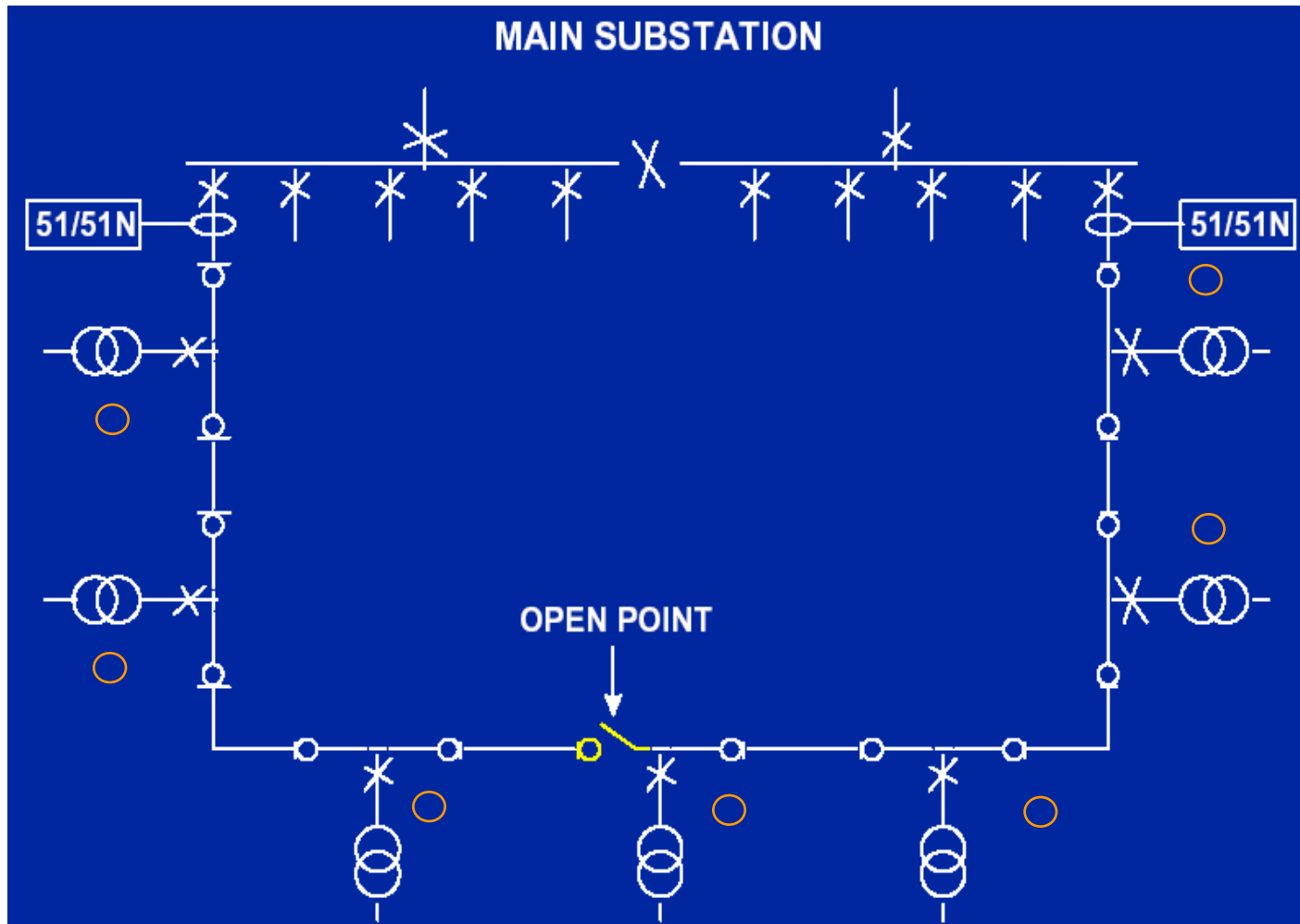


*How can we improve?*

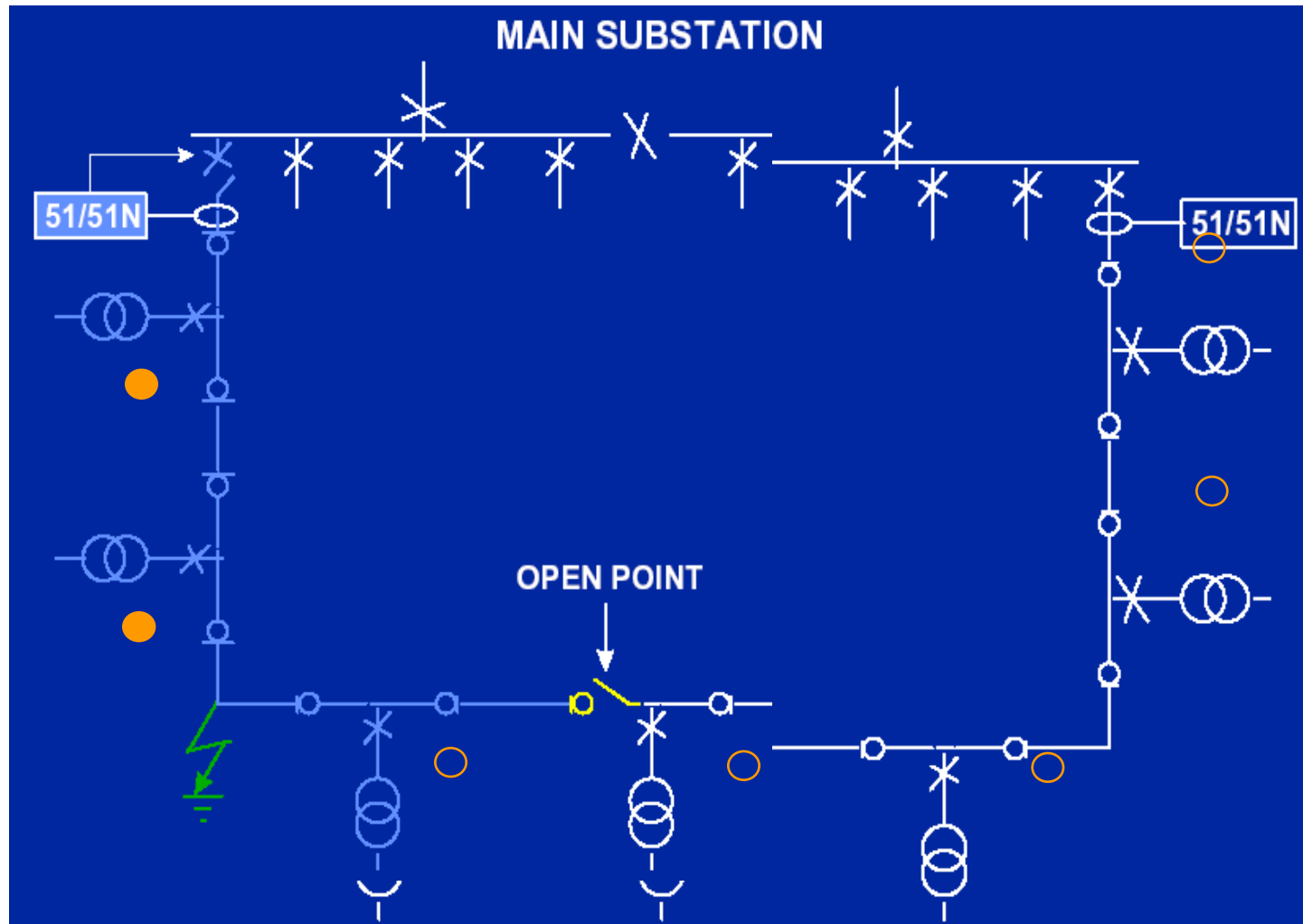
# Open ring network



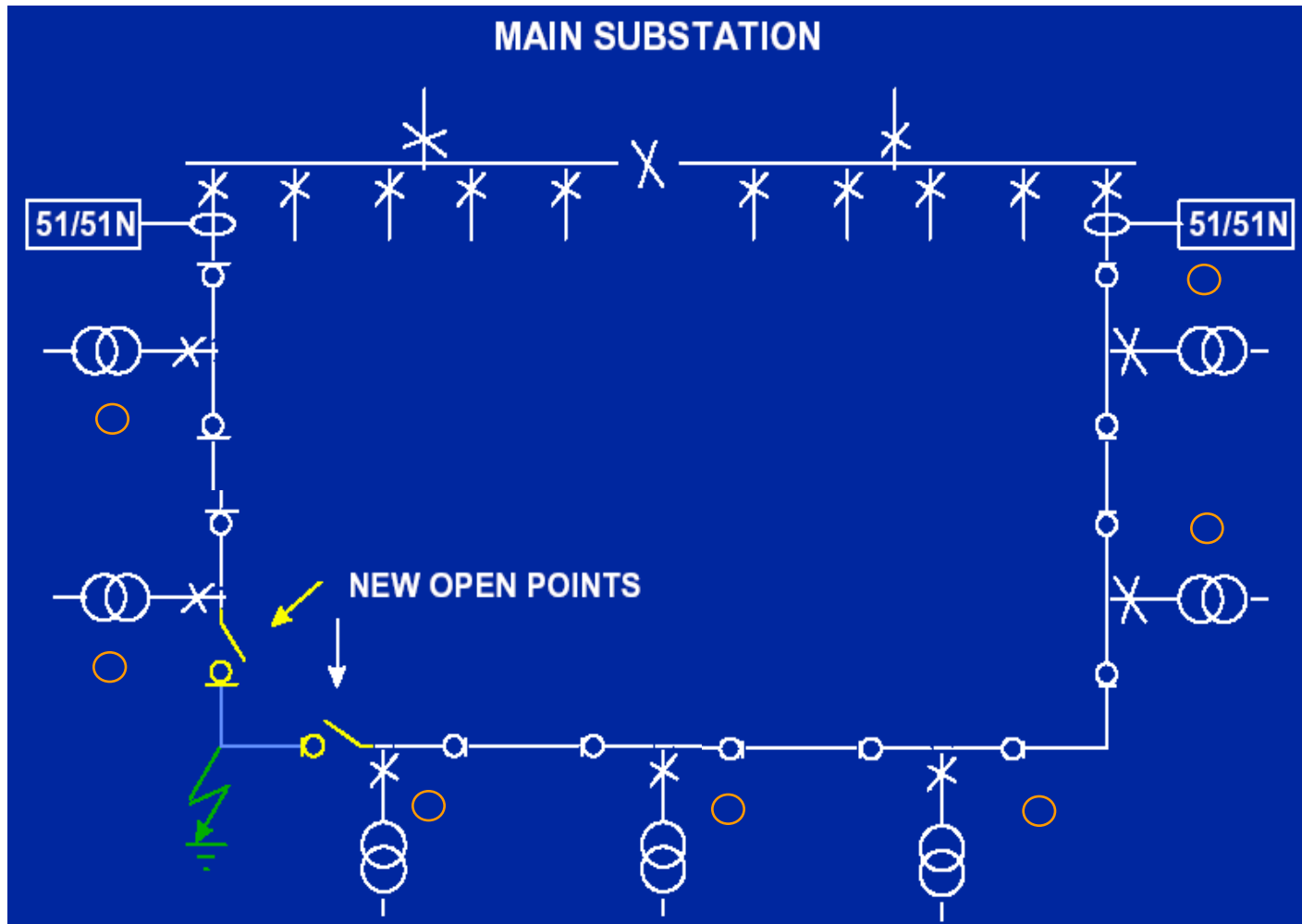
# Normal Configuration



# Earth Fault On System

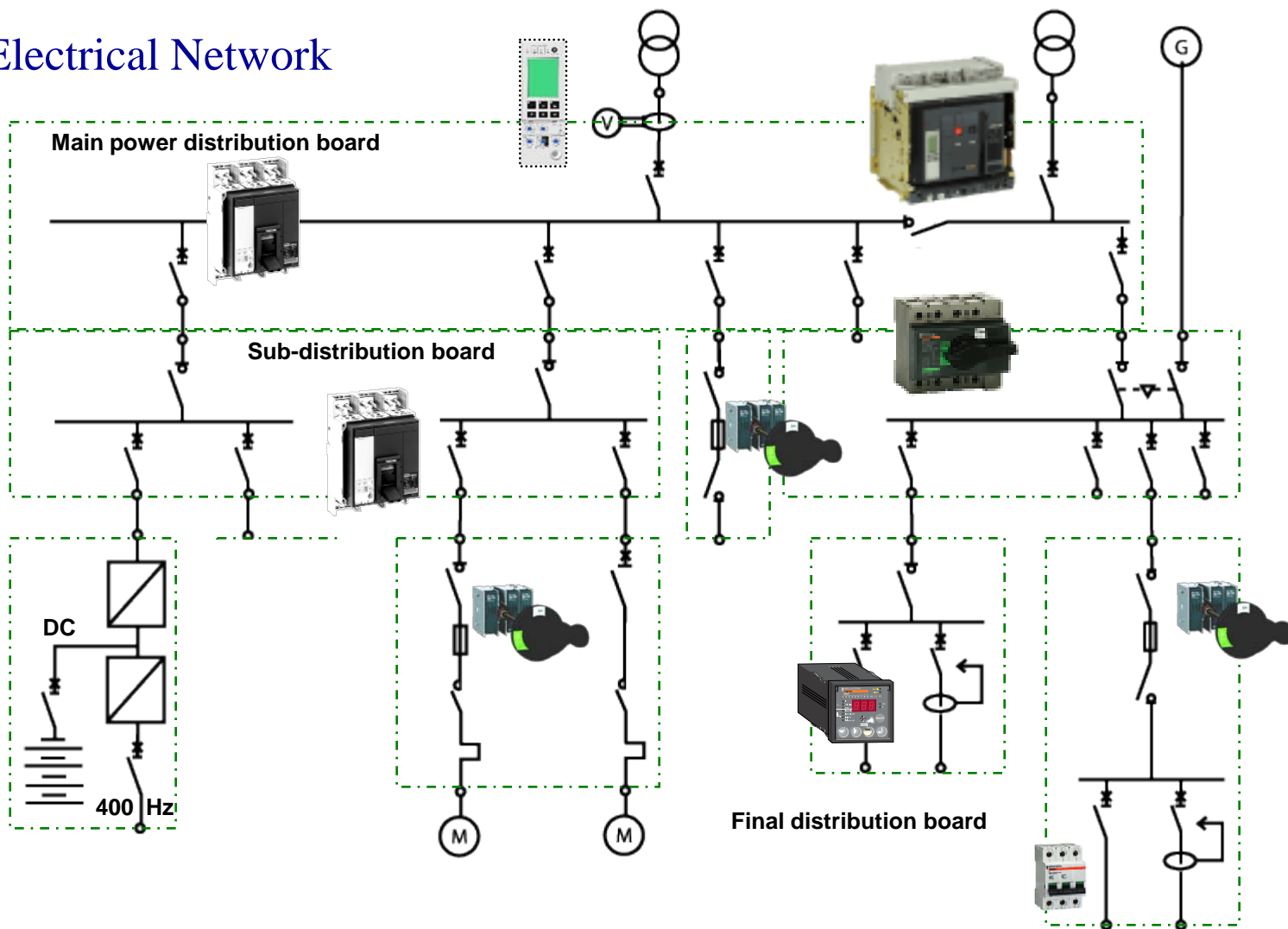


# System Re-configured



# Overview

## □ LV Electrical Network



# Basic definitions

## ❑ Circuit breaker:

Switching and current interrupting device

## ❑ Switchgear:

All equipments associated with the fault clearing process

## ❑ Control gear:

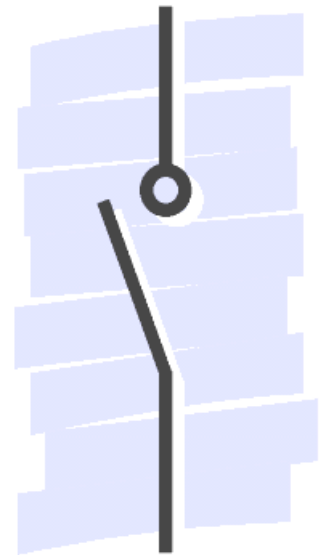
Used for switching and controlling power consuming devices

## ❑ Fault:

A defect in its electrical circuit due to which current is diverted from its intended path

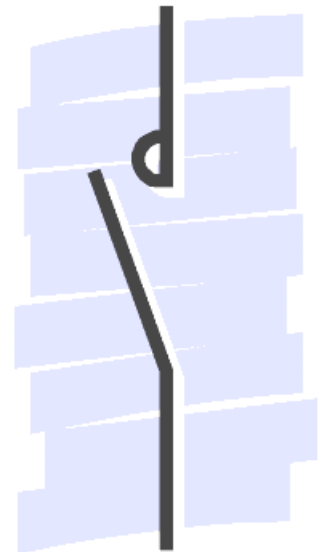
# Switch

- A mechanical switching device capable of making, carrying and breaking currents under normal conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit



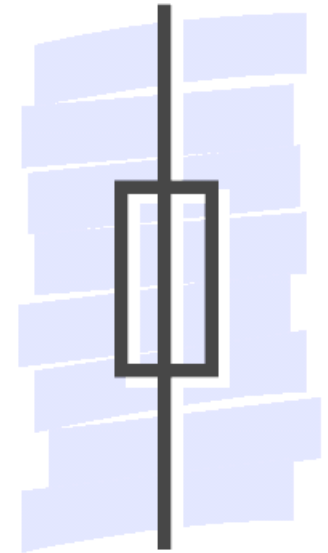
# Contactor

- A mechanical switching device having only one position of rest, operated otherwise by hand, capable of making, carrying & breaking current under normal circuit conditions including operation overload conditions



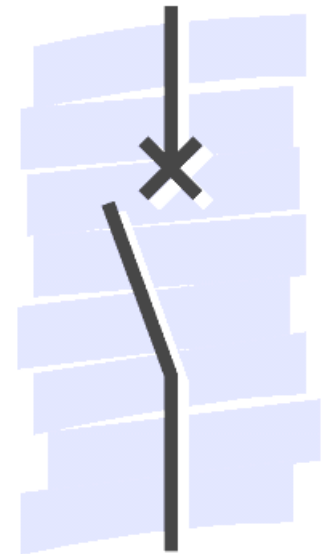
# Fuse

- A device that by fusing of one or more of its specifically designed & proportioned components opens the circuit in which its inserted by breaking the current when this exceeds a given value for a sufficient time



# Circuit breaker

- A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit

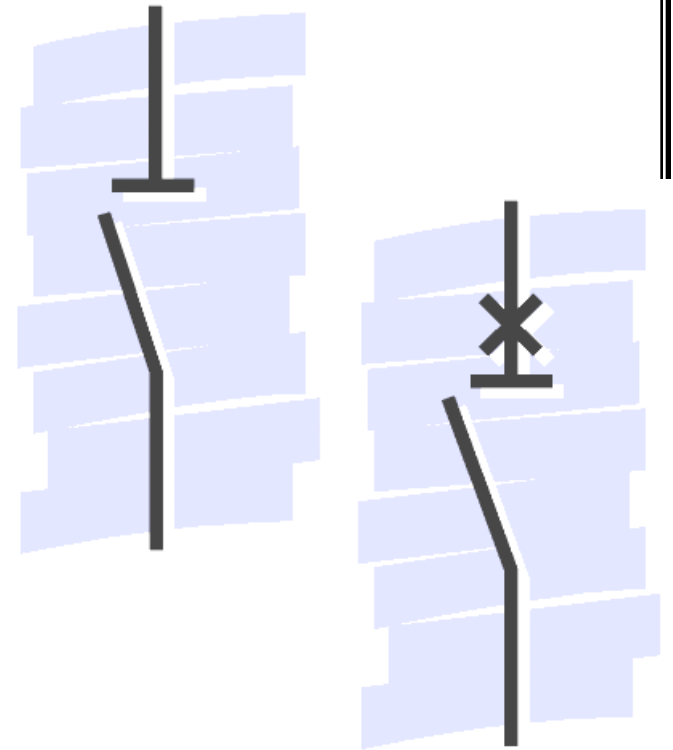


# Isolator / Disconnect

□ A mechanical switching device which, in the open position, complies with the requirements specified for the isolating function

- Leakage current
- Contact bond strength
- Impulse withstand voltage

□ The isolating function can be added to others



# Basic Functions

## ■ Isolation



*disconnector*

## ■ Control



*contactor*

## ■ Protection



*circuit breaker*

# Basic Functions

## ☐ Isolation

- Positive break indication
- Visible break

## ☐ Control

- Functional
- Emergency
- Breaking for maintenance

## ☐ Protection

- Overload
- Short circuit
- Insulation faults

# Isolation

## □ Disconnecter according to IEC 60 364 & 462 – 1

- Disconnecter: Mechanical switching device which, in open position complies with the requirements specified for isolating function
- Purpose: Isolate and separate a circuit or device from the rest of the installation

■ Disconnecter



■ Switch disconnecter

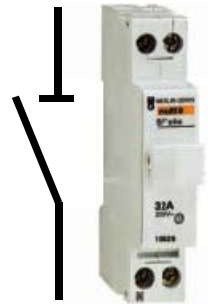


■ Circuit breaker



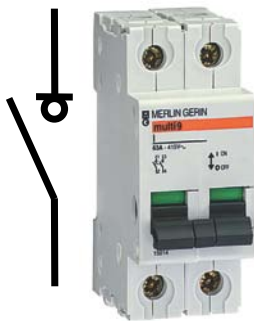
# Isolation

Disconnecter

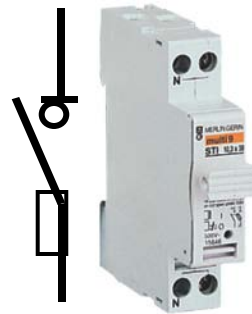


Power on ...  
... BUT no loads

Switch-disconnector



Disconnecter-fuse



Circuit breaker-disconnector



# The “functional” control

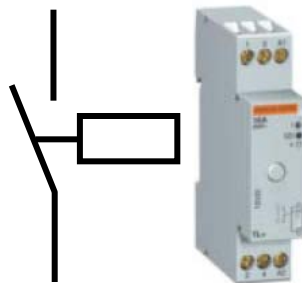
□ Purpose: Energizing or de-energizing all parts of the installation in normal operation

- Switch
- Contactor
- Impulse relay
- Circuit breaker

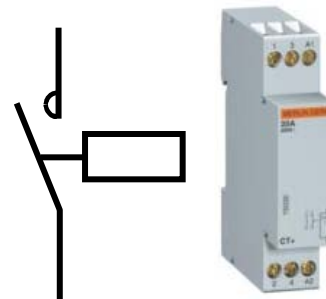
*Switch*



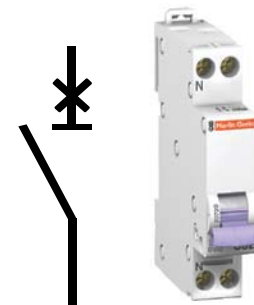
*Impulse relay*



*Contactor*



*Circuit breaker*



# Protection



*Protection  
of people*



*Protection  
of property*

# Electrical Protection as per IEC 60364 & 43

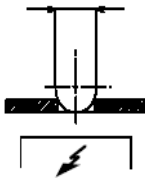














Protection of property

Purpose: to protect cables and equipments against-----

- Overloads, over currents occurring due to faulty use
- Short circuit currents occurring due to fault between the conductors

# - Protection index

- Protection of people against direct contact and protection of equipment against certain external influences is required by international standards.
- The protection index is the level of protection provided to by an enclosure against access to hazardous parts , the penetration of solid foreign bodies and of water.
- The IP code is a coding system to indicate protection index.
- It applies to enclosure of electrical equipments with a rated voltage of less then or equal to 72.5kV.

Item	Figures or letters	Meaning for protection of equipment	Meaning for protection of people	Representation
Code letter	IP			
first characteristic figure		against penetration of solid foreign bodies (not protected)	against access to hazardous parts with (not protected)	
	0	against penetration of solid foreign bodies (not protected)	against access to hazardous parts with (not protected)	
	1	diameter $\geq 50$ mm	back of the hand	
	2	diameter $\geq 12,5$ mm	finger	
	3	diameter $\geq 2,5$ mm	tool	
	4	diameter $\geq 1$ mm	wire	
	5	protected against dust	wire	
	6	sealed against dust	wire	
second characteristic figure		against penetration of water with detrimental effects (not protected)		
	0	against penetration of water with detrimental effects (not protected)		
	1	vertical water drops		
	2	water drops (15° inclination)		
	3	rain		
	4	water projection		
	5	spray projection		
	6	high power spray projection		
	7	temporary immersion		
	8	prolonged immersion		

# Fault

- ❑ A fault in an electrical equipment is defined as a defect in its electrical circuit due to which the current is diverted to the un-intended path
  
- ❑ Generally caused by breaking of conductors or failure of insulation
  
- ❑ Other causes
  - Mechanical failure
  - Accidents
  - Excessive stresses

# Fault

## □ Classification

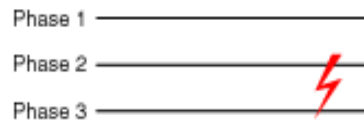
- Open circuit - most common fault
- Single line to ground fault - most common fault
- Line to line fault
- Double line to ground fault
- Three phase fault – Dead short circuit
- Three phase to ground fault – Rare fault

Faults cannot be eliminated but can be minimized

# Fault

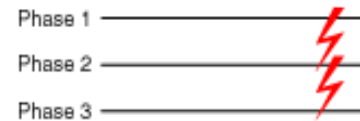
## □ Short Circuit

### *phase-to-phase Isc*



Isolated two-phase short-circuit

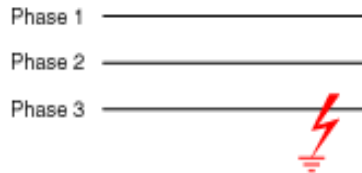
*Rare but destructive*



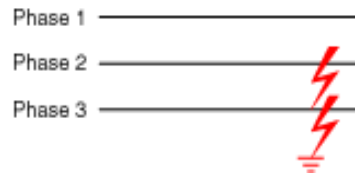
*Energy loss*

Three-phase short-circuit (5% of cases)

### *phase-to-earth Isc*



Earth single-phase short-circuit



*The Most Common*

Two-phase short-circuit (80% of cases)

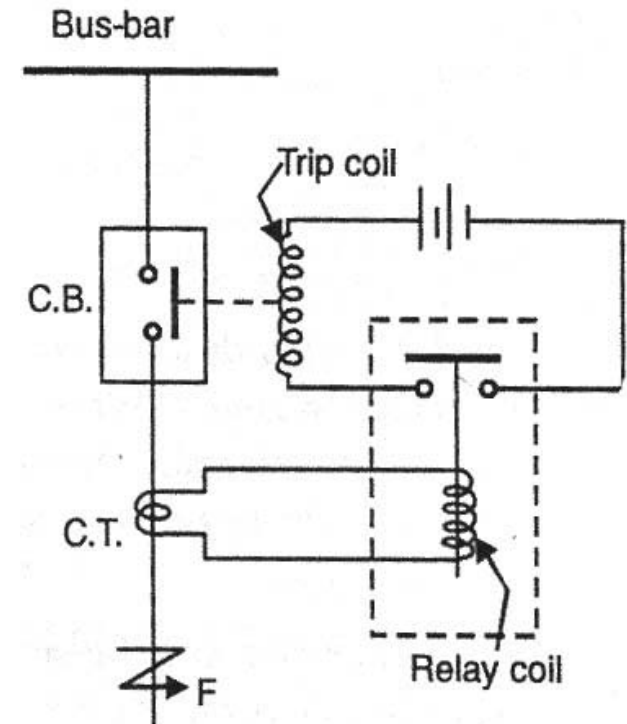
# Other disturbances

- Surges
- Under voltage and voltage sags
- Frequency fluctuations
- Harmonics
- Overload
- Transients

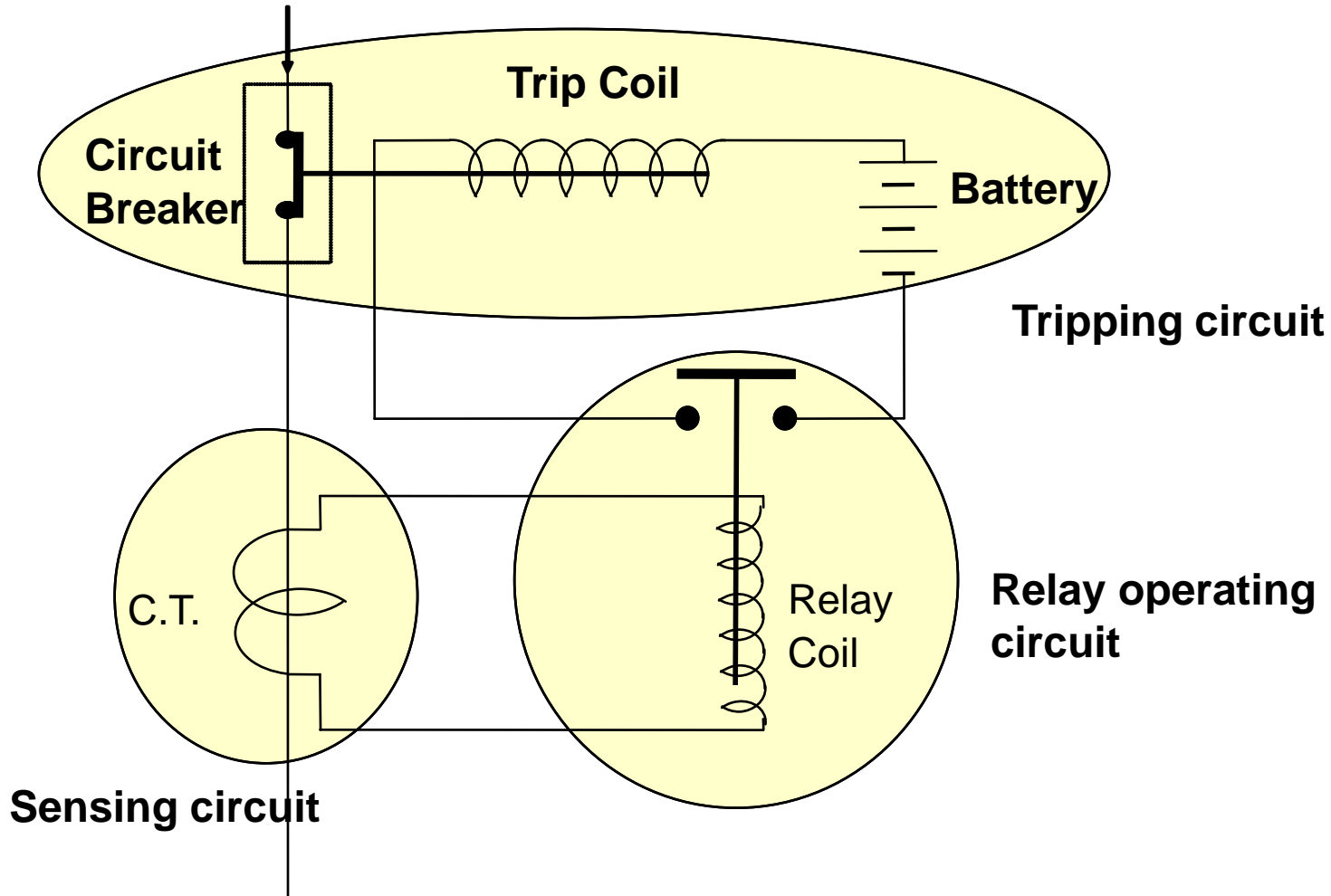
# Basic Operation of Circuit Breaker

Operating Principle:

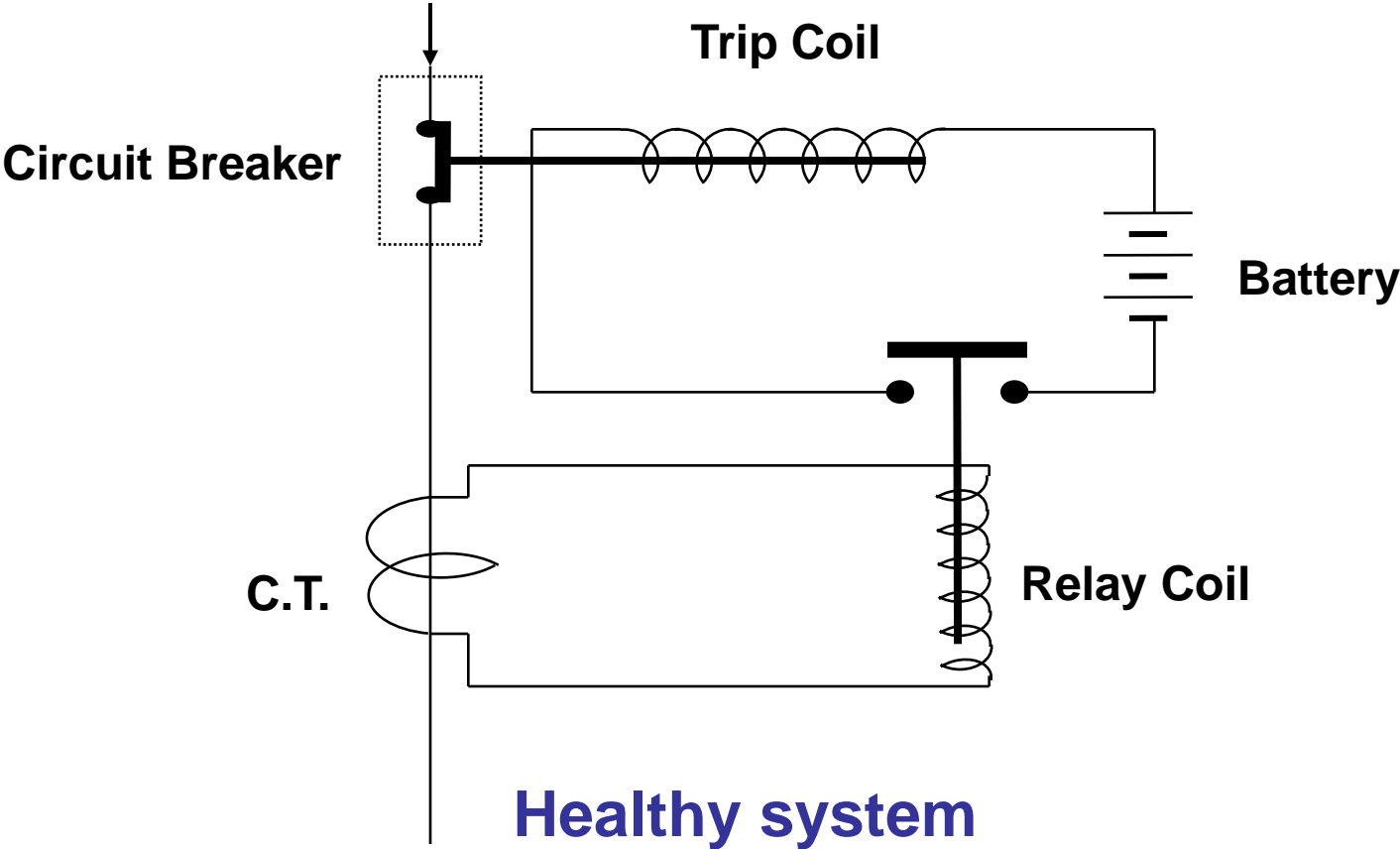
- It essentially consists of fixed and moving contacts, called electrodes
- When a fault occurs on any part of the system the trip coils of the circuit breaker get energised through relays and the moving contacts are pulled apart by some mechanism, thus opening the circuit



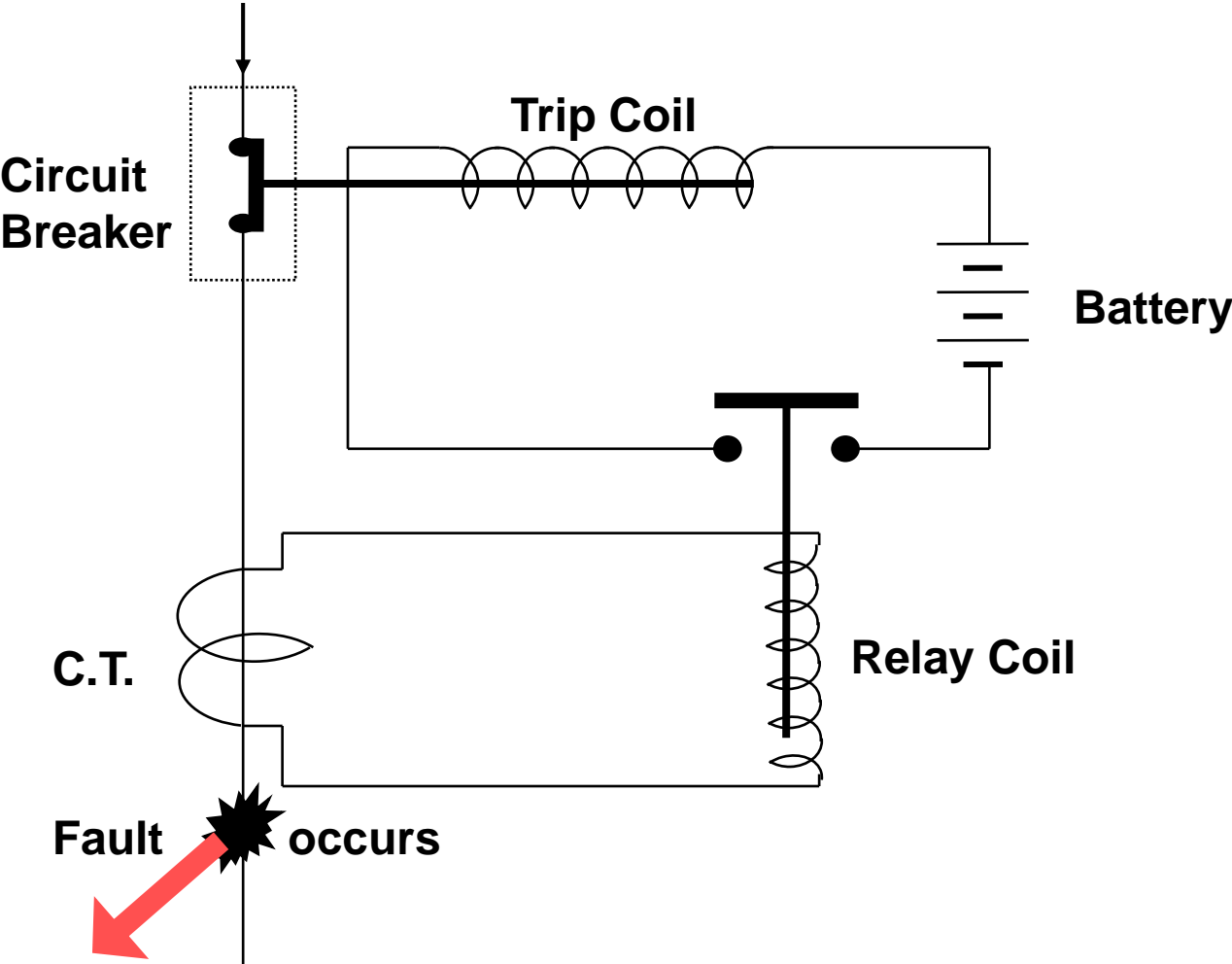
# Fault clearing process



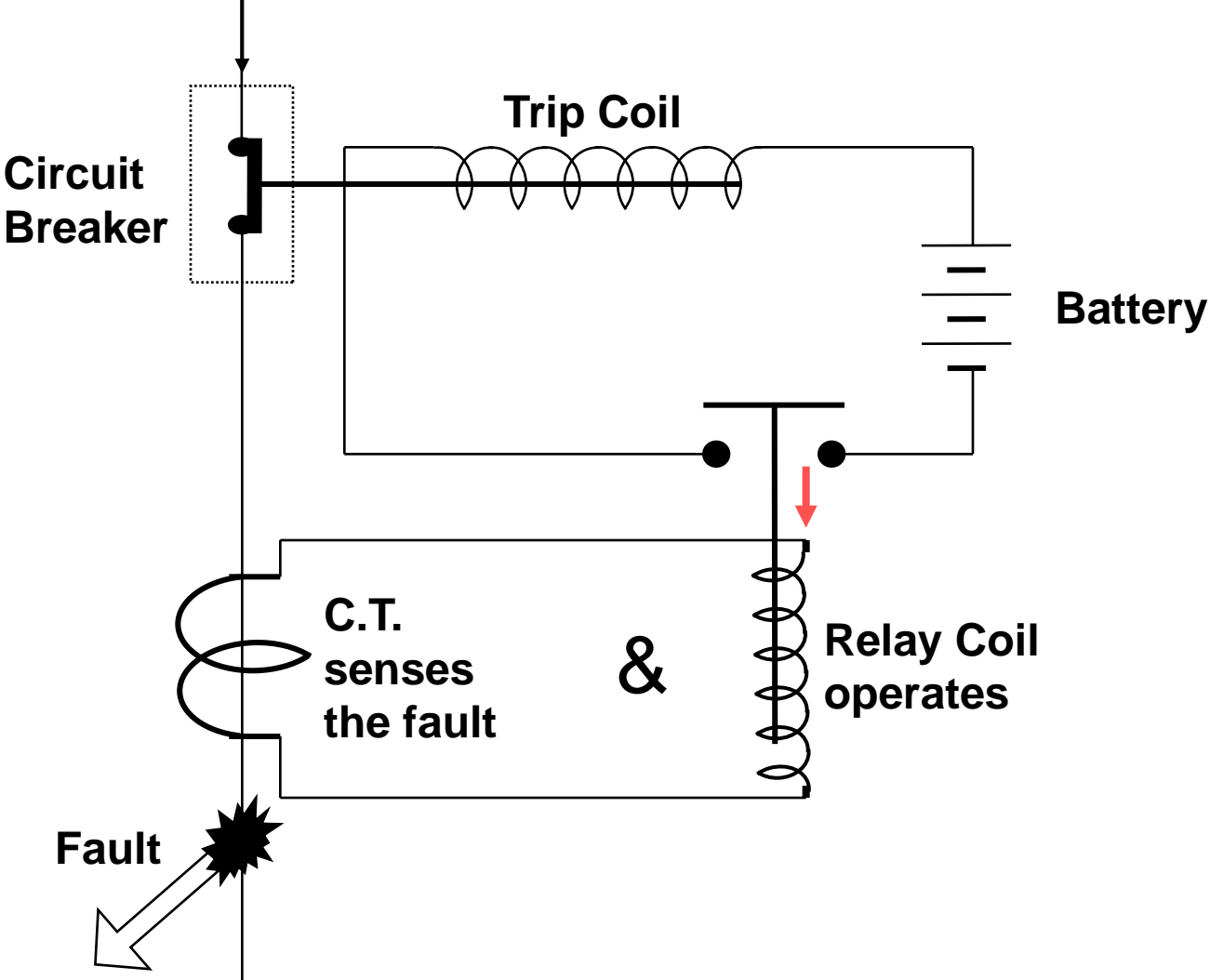
# Fault clearing process



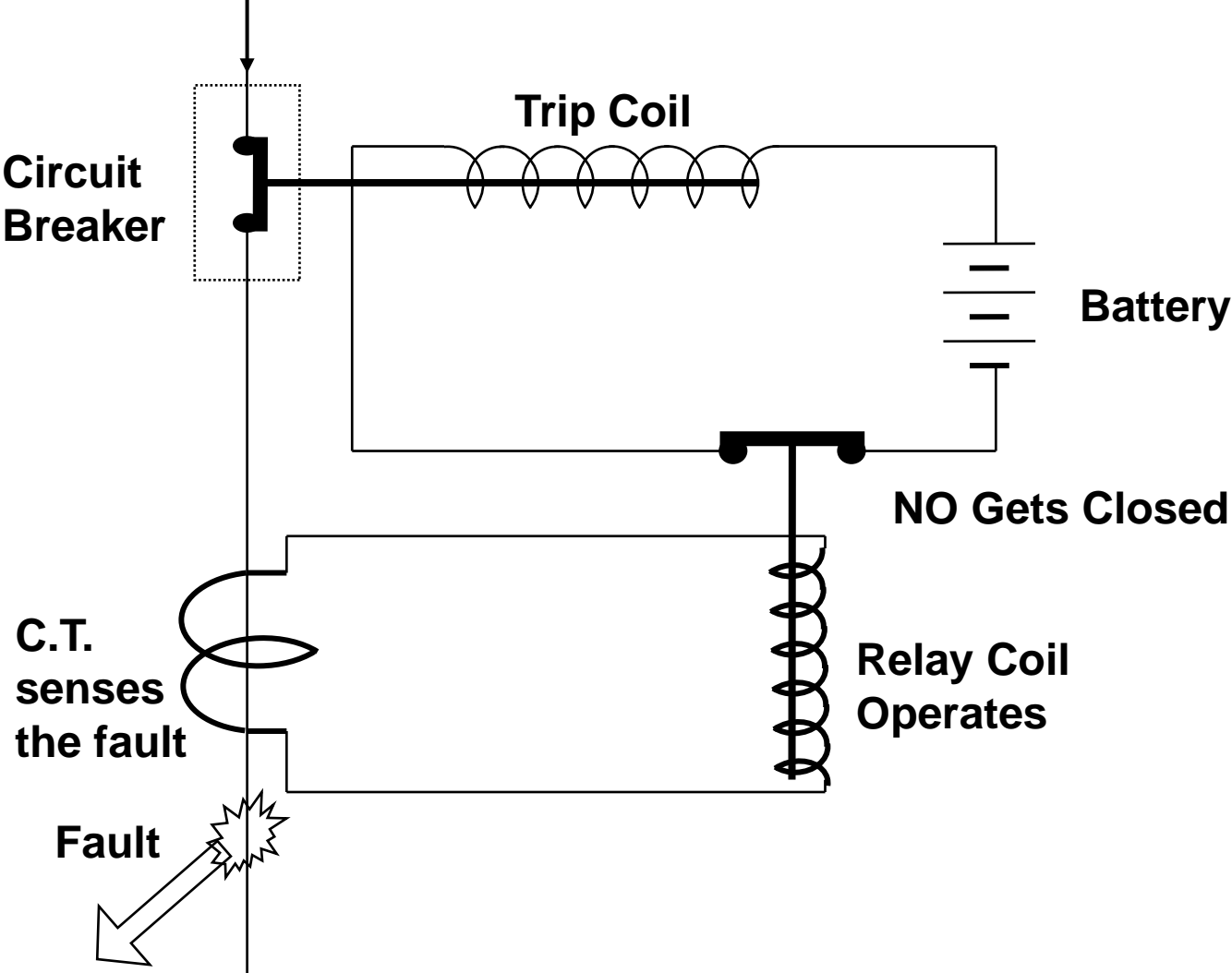
# Fault clearing process



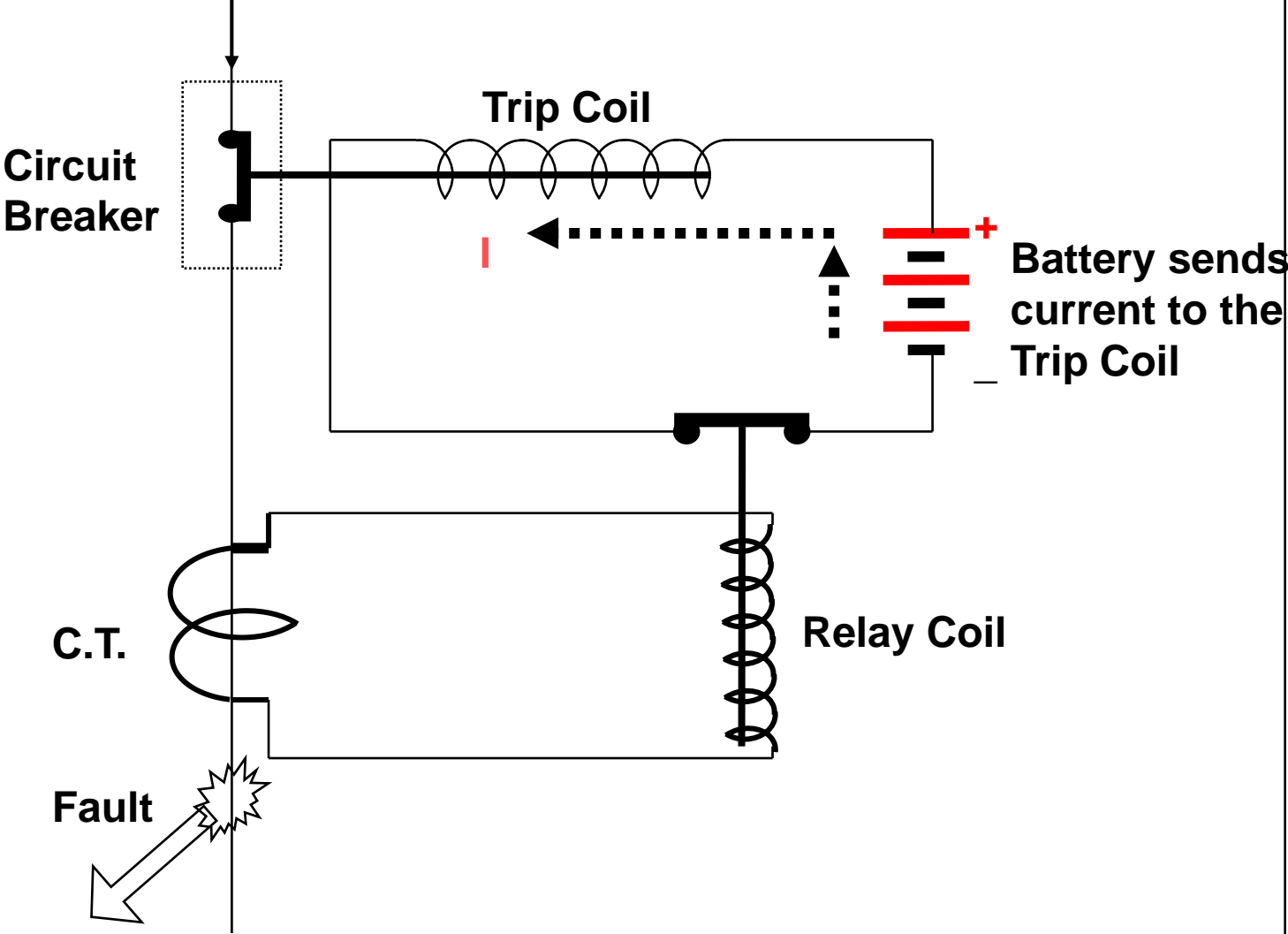
# Fault clearing process



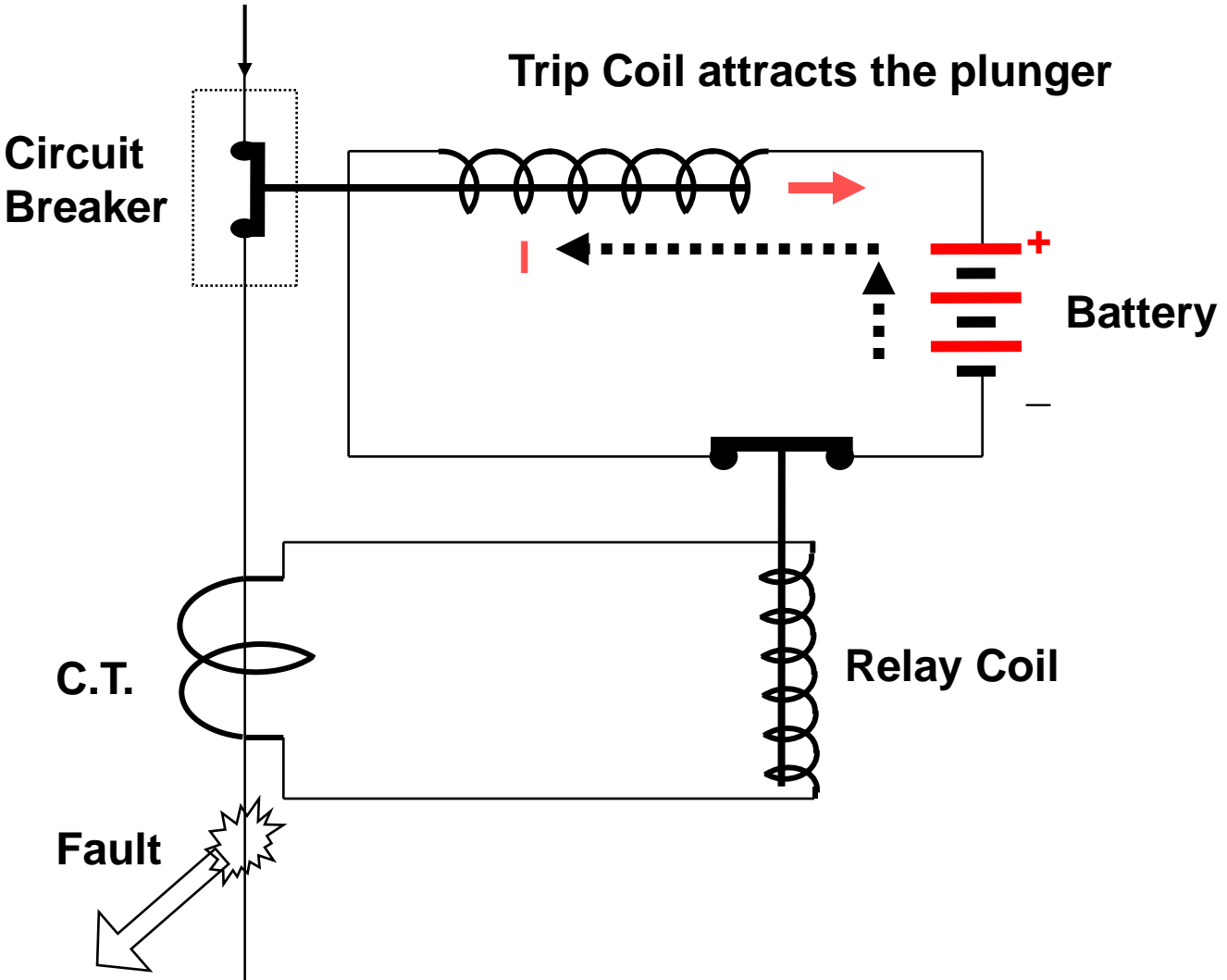
# Fault clearing process



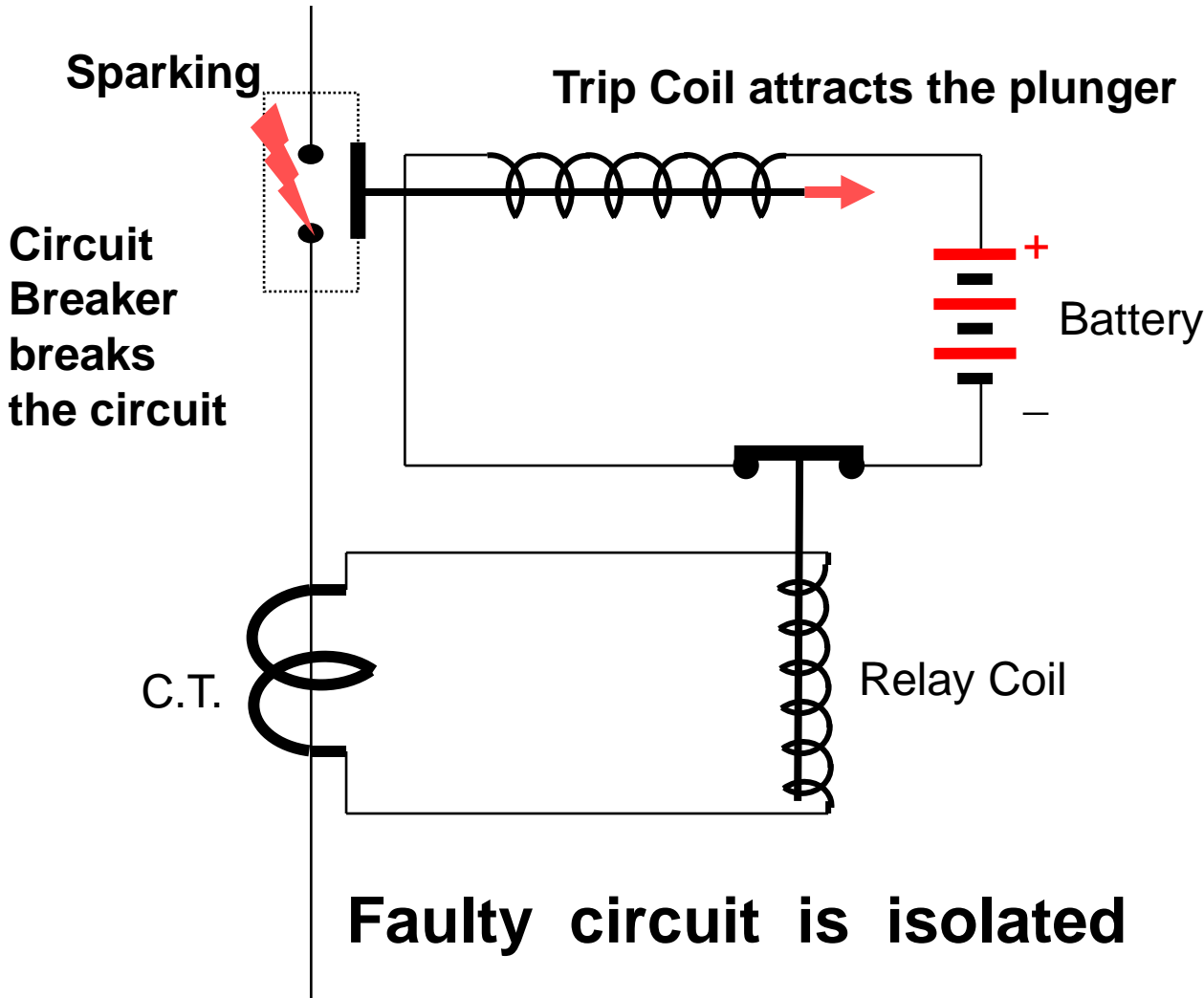
# Fault clearing process



# Fault clearing process



# Fault clearing process

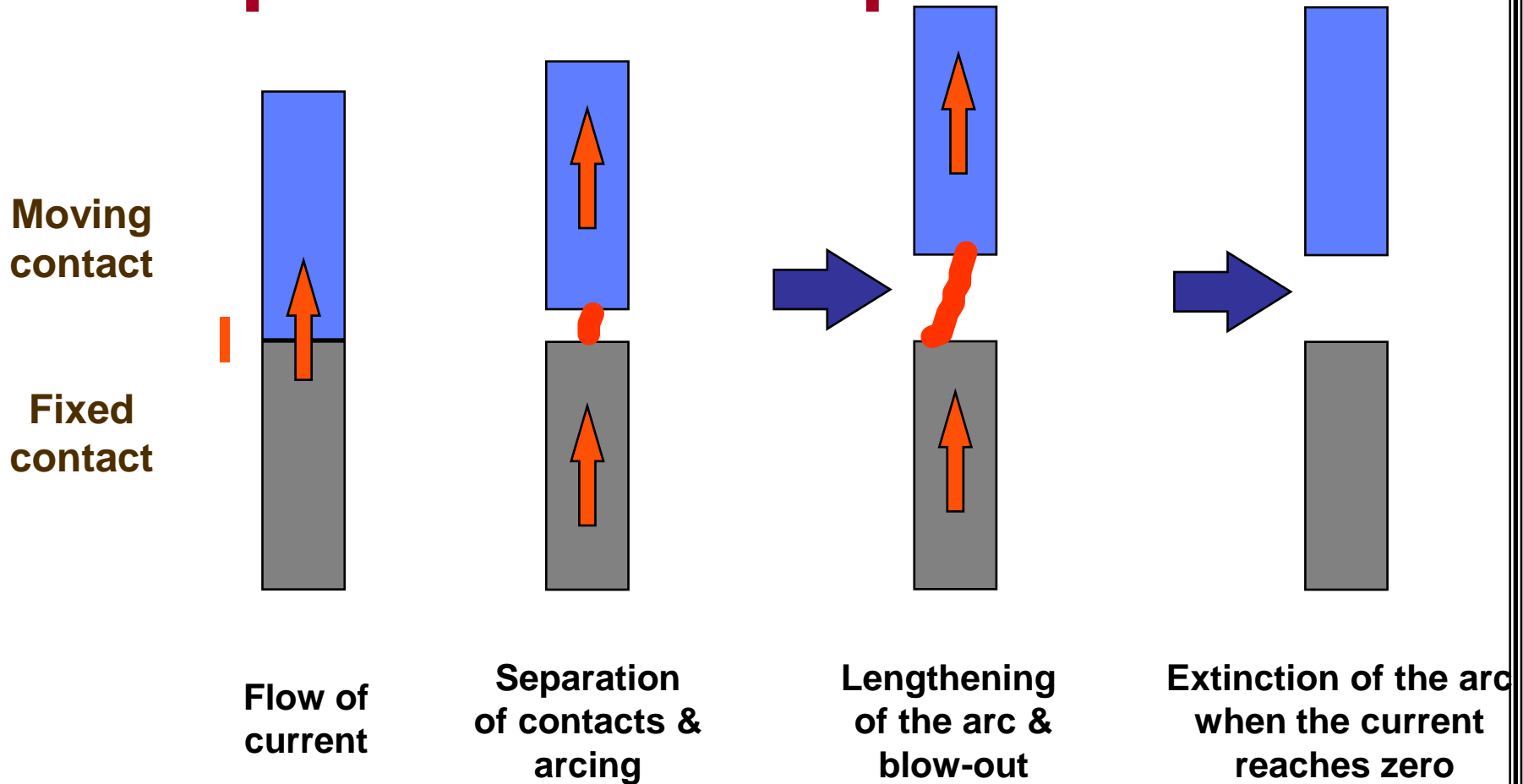


# - Arc breaking techniques

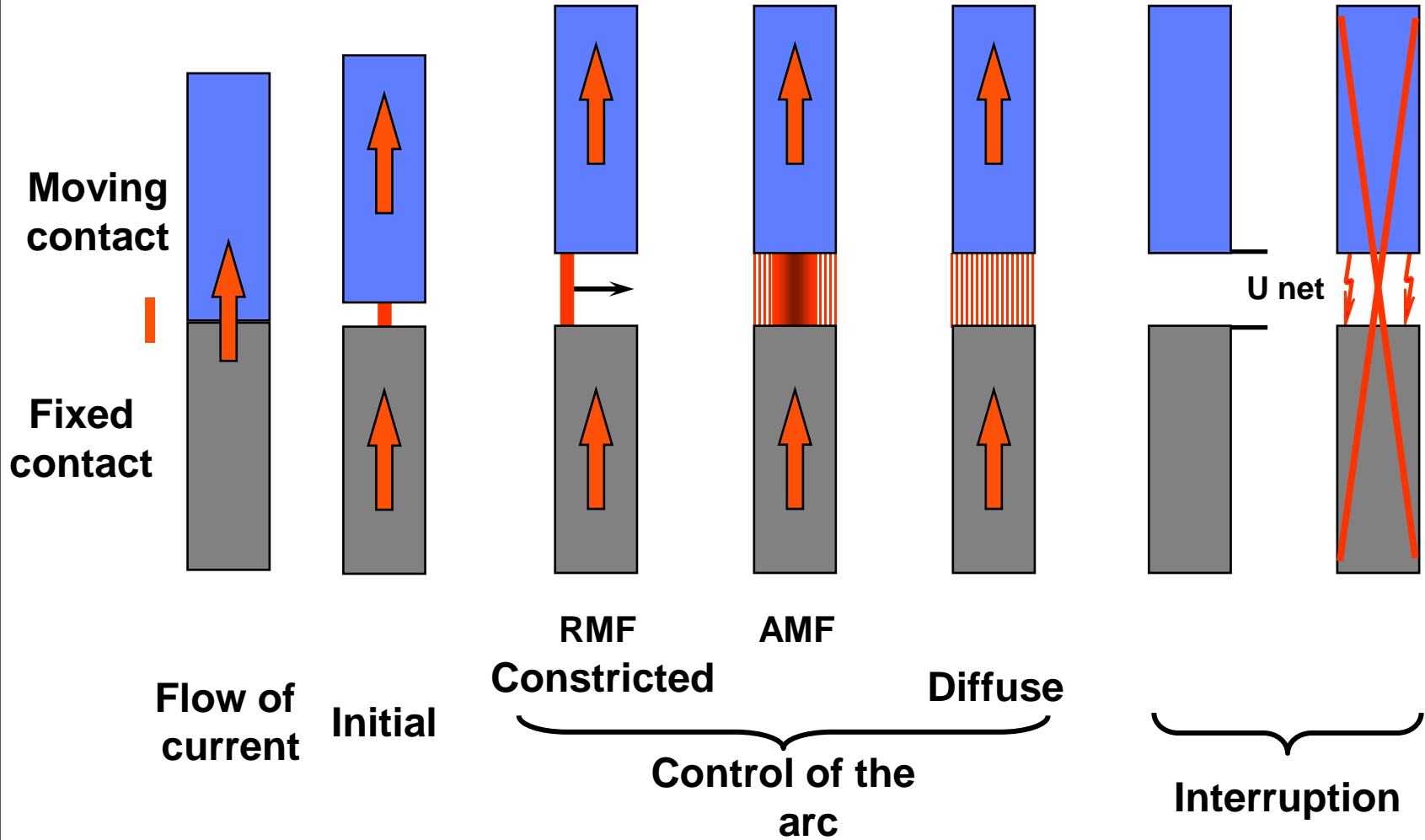
- An arc is created when the voltage between two conductors is greater than the maximum dielectric withstand of the medium between the conductors
- Irreversible deterioration in solid insulating materials
- Ionization of the medium between the contacts
  - air
  - SF6 gas
  - oil
  - vacuum: vaporization of metal on the contacts
- The ionized insulating medium becomes temporarily conductive
- Presence of an arc voltage according to the ionized medium and the type of electrodes

*MV breaking techniques...*

# -the "puffer" technique

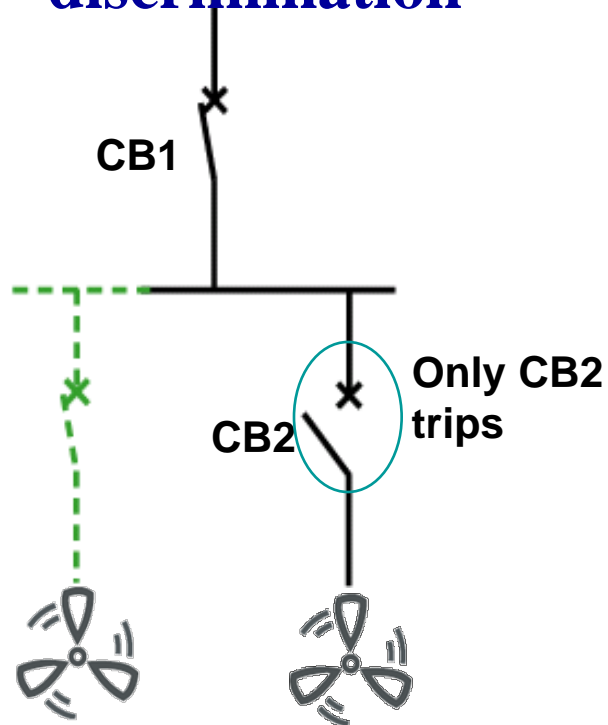


# - the vacuum technique



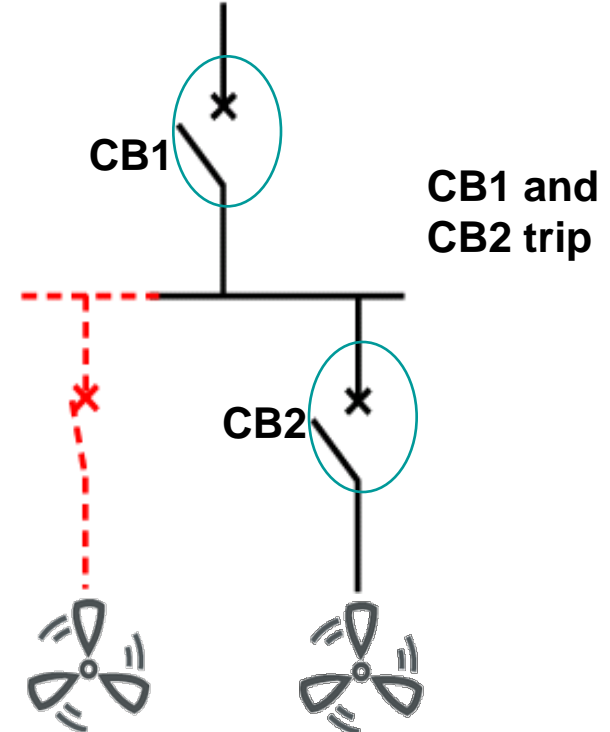
# Discrimination

Total discrimination



The power supply to the other feeders is still ensured

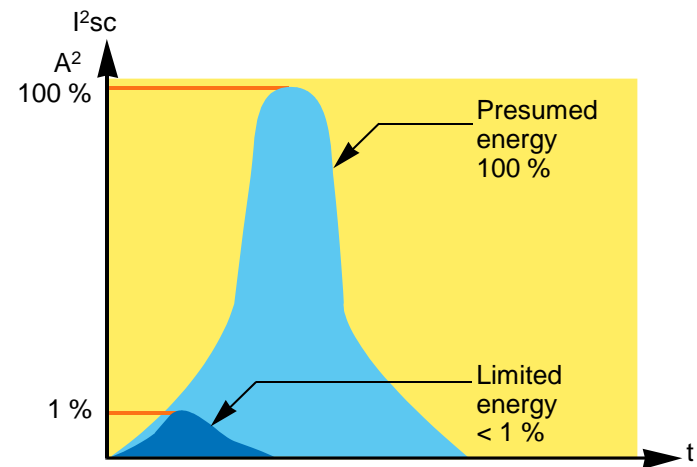
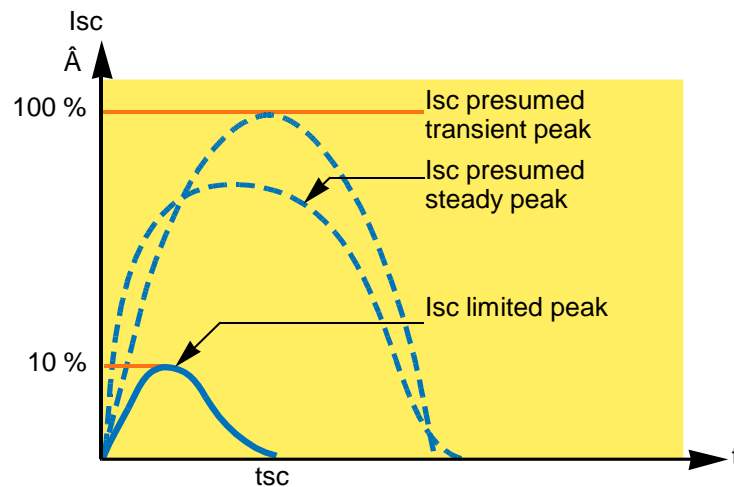
No discrimination



The power supply to the other feeders is no longer ensured

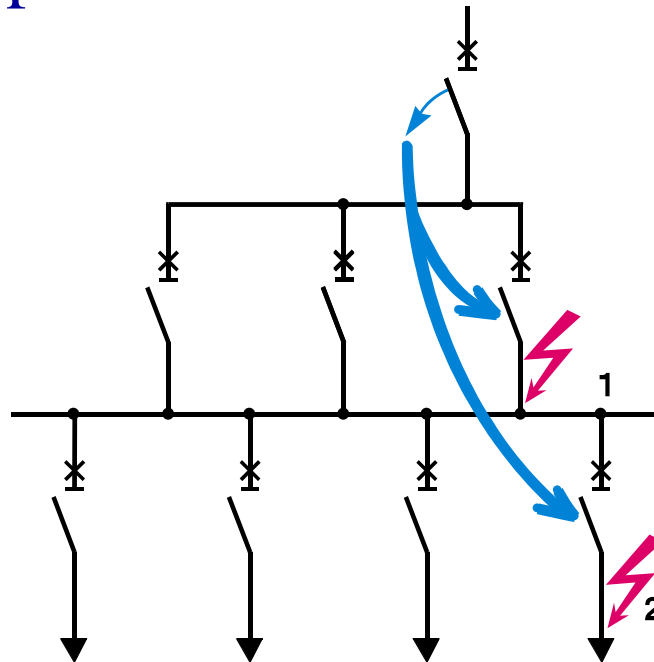
# Current limitation

- ❑ Technique that allows harmful effects of short circuit currents to be diminished
- ❑ Limitation reduces effects of following types
  - Electromagnetic: reduction in EMC disturbances
  - Mechanical: reduction in deformation and / or breaks
  - Thermal: rise in the span of trunkings



# Cascading

- ❑ The limiting upstream breaker helps the downstream circuit breakers to open
- ❑ Technique that allows for the cost of LV electrical distribution to be optimized

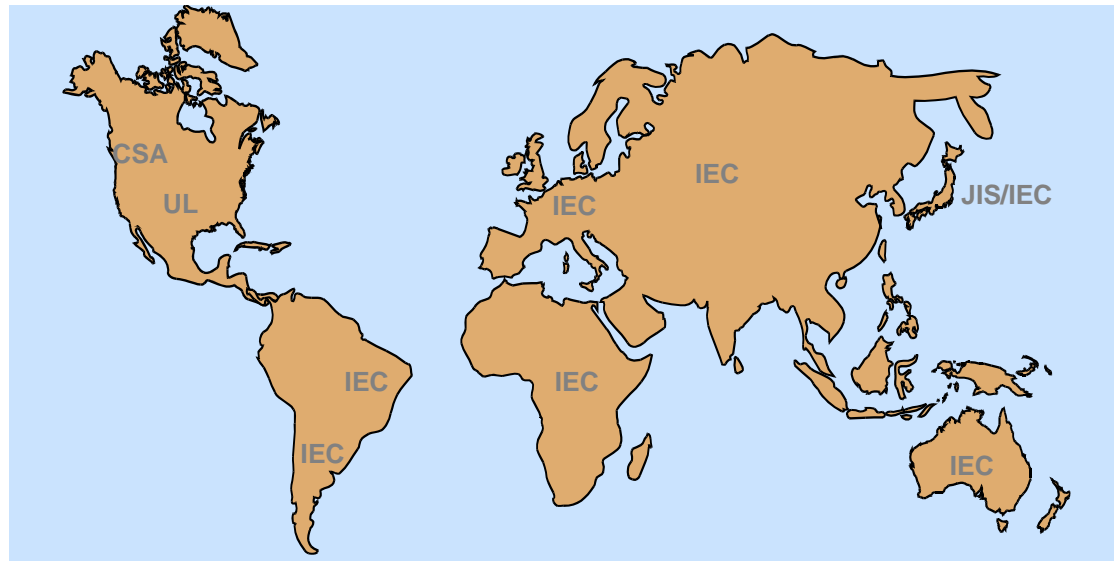


# IEC 60 947 - 2

Standard IEC 60947- 2

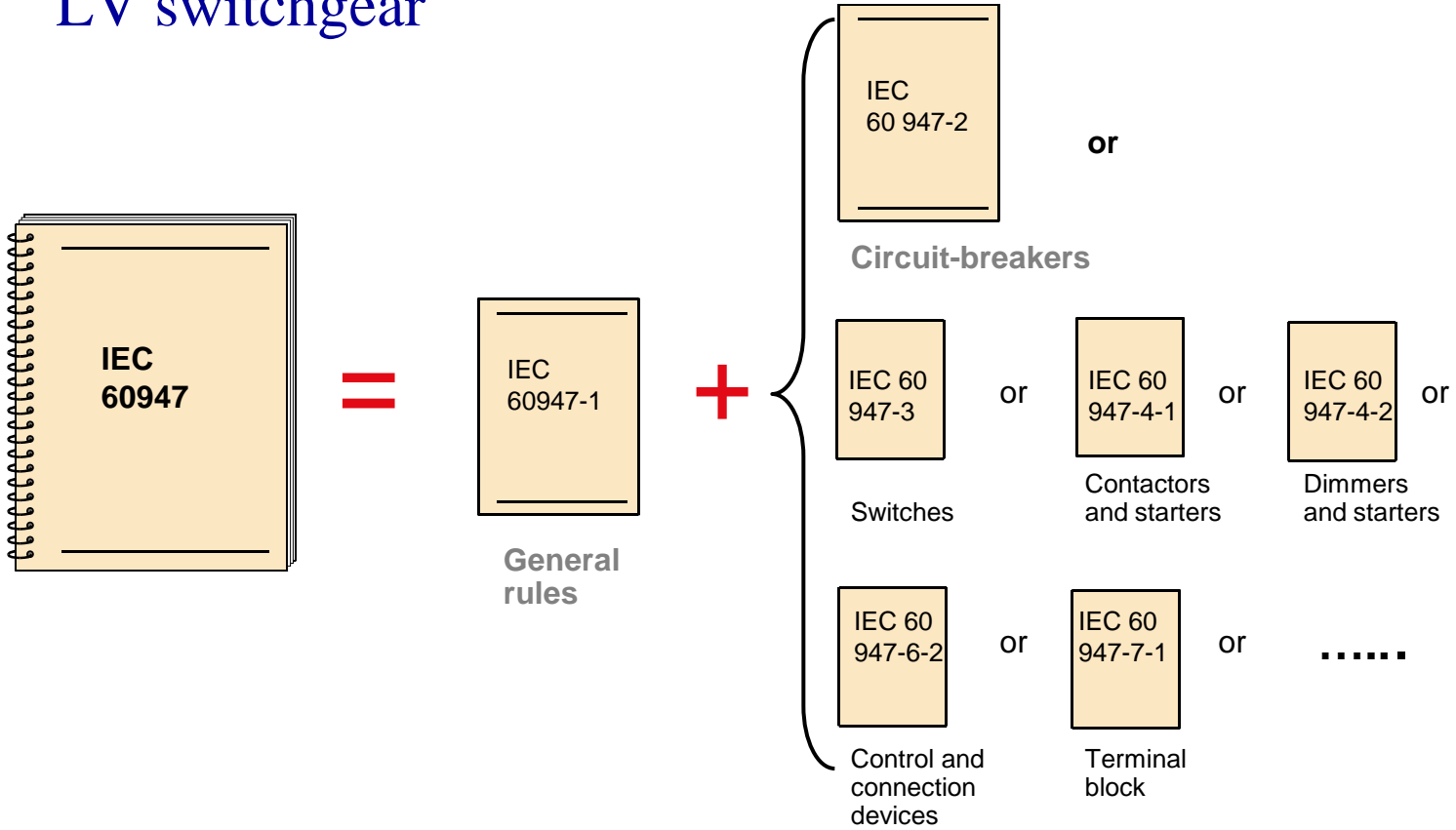
- ❑ Came into force in 1989
- ❑ Takes into account the circuit-breaker main technological upgrades
- ❑ Is internationally recognized and approved

and is applied in the majority of countries (> 100)



# IEC 60 947 - 2

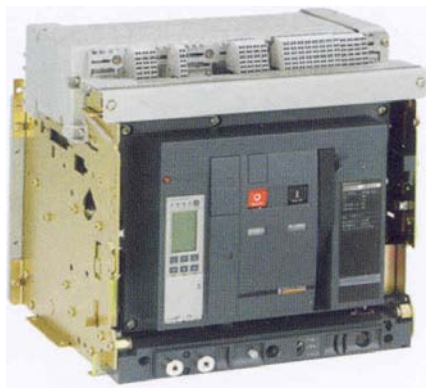
IEC 60 947 – 2 is a part of a set of 7 standards characterizing LV switchgear



# IEC 60 947 - 2

## □ The Scope

- « Standard IEC 60947-2 applies to circuit-breakers, the main contacts of which are intended to be connected to circuits, the rated voltage of which does not in exceed 1000 V AC or 1500 DC; ... »



- The standard applies to circuit breakers intended for use by experienced operators

# IEC 60 947 - 2

## □ Definition – Circuit breaker

- Mechanical switching device, capable of making, carrying and breaking currents under **normal** circuit conditions and also making, carrying for a **specified time** and breaking currents under **specified abnormal** circuit conditions such as those of short circuit [441- 14 - 20]

# IEC 60 947 - 2

- Standard IEC 60 947 – 2 defines
- The circuit breaker classification
  - According to utilization category A or B
  - According to design type - air circuit breaker, moulded case circuit breaker
  
- The circuit breaker mechanical and electrical data:  
size, trip unit, etc

# IEC 60 947 - 2

## Circuit breaker classification

Utilization category A	Utilization category B
<p>Circuit breaker not specifically intended for discrimination</p> <ul style="list-style-type: none"><li>■ Without an intentional short time delay</li><li>■ Without short time withstand current</li></ul>	<p>Circuit breaker specifically intended for discrimination</p> <ul style="list-style-type: none"><li>■ With intentional short time delay (adjustable)</li><li>■ With short time withstand current</li></ul>

## IEC 60 947 – 2, Definitions Terminology / Vocabulary

□ Extract form appendix K of standard IEC 60947 - 2

Voltage	Ue Ui Uimp	Rated operational voltage Rated insulation voltage Rated impulse withstand voltage
Current	In Ith Ithe	Rated current Conventional free – air thermal current Conventional enclosed thermal current
Short - Circuit	Icm Icu Ics Icw	Rated short circuit making capacity Rated ultimate short circuit breaking capacity Rated service short circuit breaking capacity Rated short time withstand current
Trip unit	Ir 1.05xIr 1.30xIr Isd Ii	Adjustable overload setting current Conventional non – tripping current Conventional tripping current Short time delay tripping setting current Instantaneous tripping setting current

# Starters and contactors as per IEC 60 947 - 4

## □ Scope:

- Applies to the types of equipments listed whose main contacts are intended to be connected to the circuits the rated voltage of which does not exceed 1000 V A.C or 1500 V D.C
- Starters and / or contactors dealt with in this standard are not normally designed to interrupt short circuit currents.
- Therefore suitable additional short circuit protection is recommended
- AC / DC Contactors, AC motor starters, DOL, reduced voltage AC, Star delta, rheostat rotor starters.....

----- Source IEC 60 947 - 4

# Starters and contactors as per IEC 60 947 - 4

## ❑ Electromagnetic Contactor

- A contactor is a mechanical switching device having only one position of rest, operated otherwise by an electromagnet, capable of making carrying and breaking currents under normal circuit conditions including operating overloads.



## ❑ Starter

- A starter is a combination of all switching means necessary to start and stop a motor in combination with suitable overload protection

-----Source IEC 60 947 - 4



# Characteristics of Contactor and starters

- Characteristics of contactor and starter are stated in following terms, wherever applicable
  - Type of equipment (Contactor, DOL, Star – Delta.....)
  - Rated and limiting values for main circuit
  - Utilization category
  - Control circuits
  - Auxiliary circuits
  - Relays and releases
  - Co ordination with SCPD
  - Over voltages.....

-----Source IEC 60 947 - 4

# Low voltage Industrial Control

- Contactors & overload relays
- MPCB's for motor protection
- Variable speed drives & Soft starters
- Motor starters
- Control Stations
- MMI equipments
  - Push buttons
  - Pilot & indicator lamps
  - MMI
  - Intelligent relays
- Detection
  - Limit switches,
  - Proximity & optical sensors
  - Encoders, etc



*Thank you for your  
attention*



**And don't hesitate to mail or ask at any  
time**

**[ravinder.negi@in.schneider-electric.com](mailto:ravinder.negi@in.schneider-electric.com)**