EA Electrification Academy

Introduction to Direct Current Applications

In this lesson, you will have an overview of the basics concepts and functionality of direct current circuit breakers. Upon completion of this module, you will be able to recognize DC breakers technology to further discuss its application.

INTRODUCTION

To get started

BREAKING TECHNOLOGY

Direct Current Breaker

FAULTS IN DC CIRCUITS

Interrupting Direct Current

CIRCUIT BREAKER TECHNOLOGY

LV Circuit Breaker Technology

MV Circuit Breaker Technology

ABB SOLUTION

ABB Offer

SUPPORT MATERIAL

Support Material

TEST YOUR KNOWLEDGE

Final Quiz

Lesson 1 of 8

To get started

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Welcome to this Electrification Academy lesson **Introduction to Direct Current Applications**!

Let's get started.

First, check if this module is for you. Select the box that is applicable:

- ☐ You are in a marketing and/or sales position that brings you to meet and interact with clients potentially needing DC solutions.
- ☐ You work with DC applications as a solution architect.
- ☐ You are building your competence around DC solutions and applications.
- ☐ You are generally interested in ABB direct current solutions.

If you checked any of the boxes above, this lesson is for you. It will take 20 minutes and will give you the ability to:

- Underline DC breakers technology.
- Discuss ABB offering for DC applications in low and medium voltage.
- Attend advanced lessons and webinars about DC solutions to further build your competence

CONTINUE

Lesson 2 of 8

Direct Current Breaker

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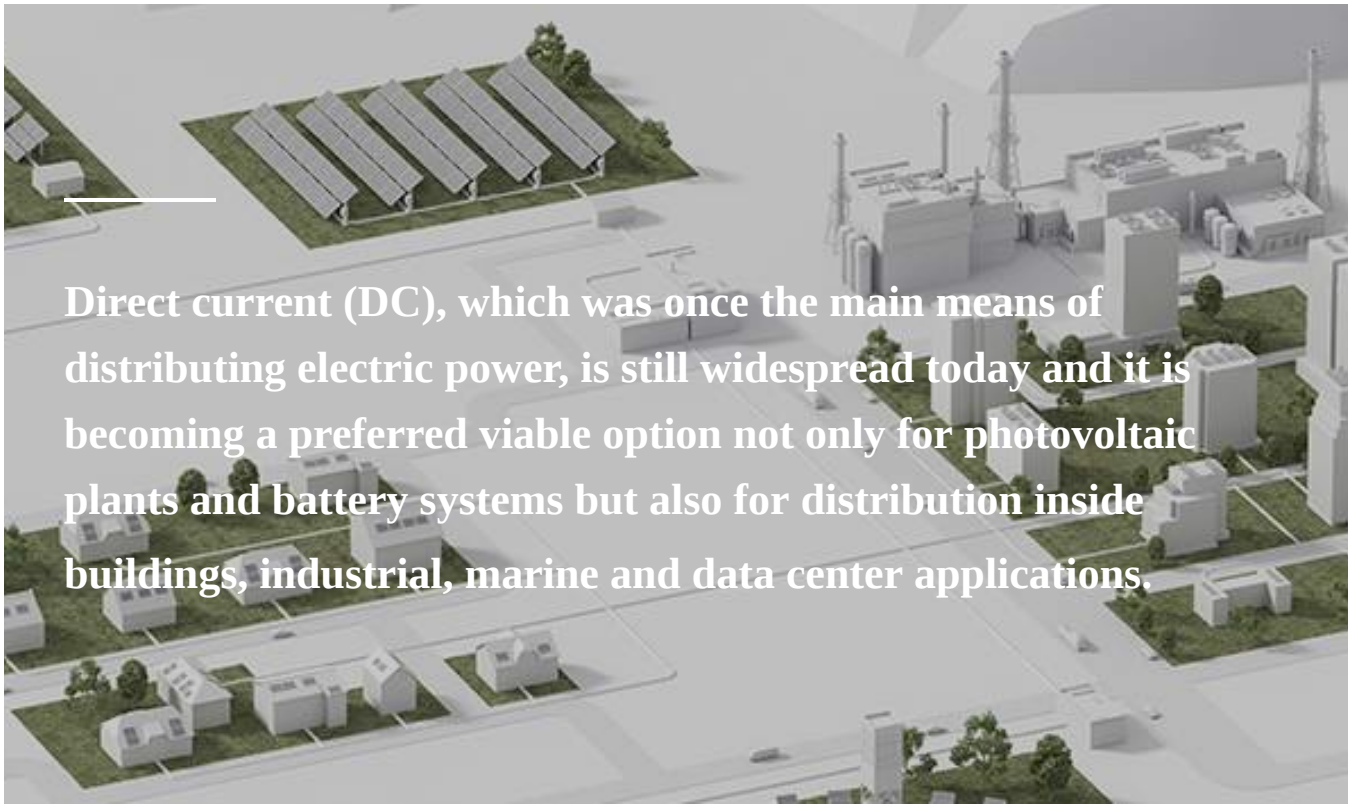


In this scenario, a thorough analysis of fault conditions and dedicated protection devices for DC system must be considered to properly safeguard assets.

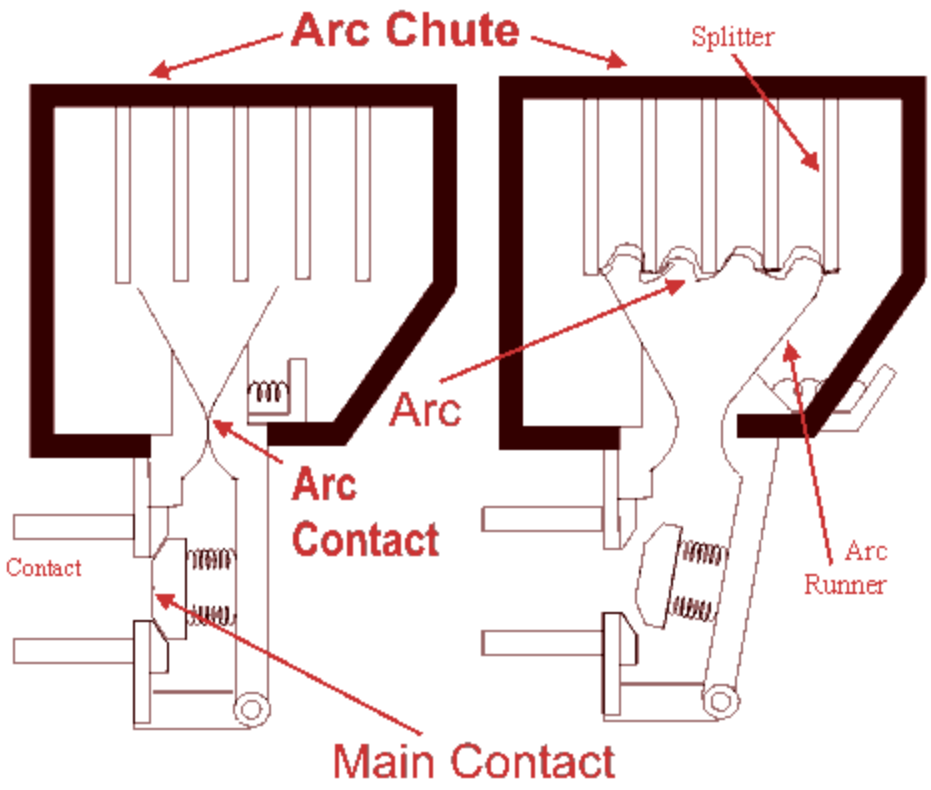
DC Breaker Technology

There are three major types of circuit breakers technologies that are relevant to DC applications, but in this lesson you will explore the air arc chute circuit breaker that is by far the most dominant circuit breaker technology in DC applications.

Electro-mechanical	• Air arc chute circuit breaker • Vacuum circuit breaker
Solid-state	Solid-state circuit breaker

Hybrid	That is a combination of solid-state and electromechanical circuit breaker

ABB offering solution - air arc chute circuit breakers



This kind of circuit breaker uses electromechanical contacts to achieve the required circuit isolation, while the electric arcs generated when the contacts open is used to help to dissipate energy stored in circuit inductance.

1

DC and its challenge...

Interrupting a fault in DC presents different challenges than interrupting an AC system. Can you guess why is that?

- ○ The current is stronger in a DC circuit.
- ○ The arc extinction in DC is particularly more difficult.
- ○ The voltage is stronger in a DC circuit.
- ○ The arc extinction in AC is particularly more difficult.

SUBMIT

Complete the content above before moving on.

Interrupting Direct Current

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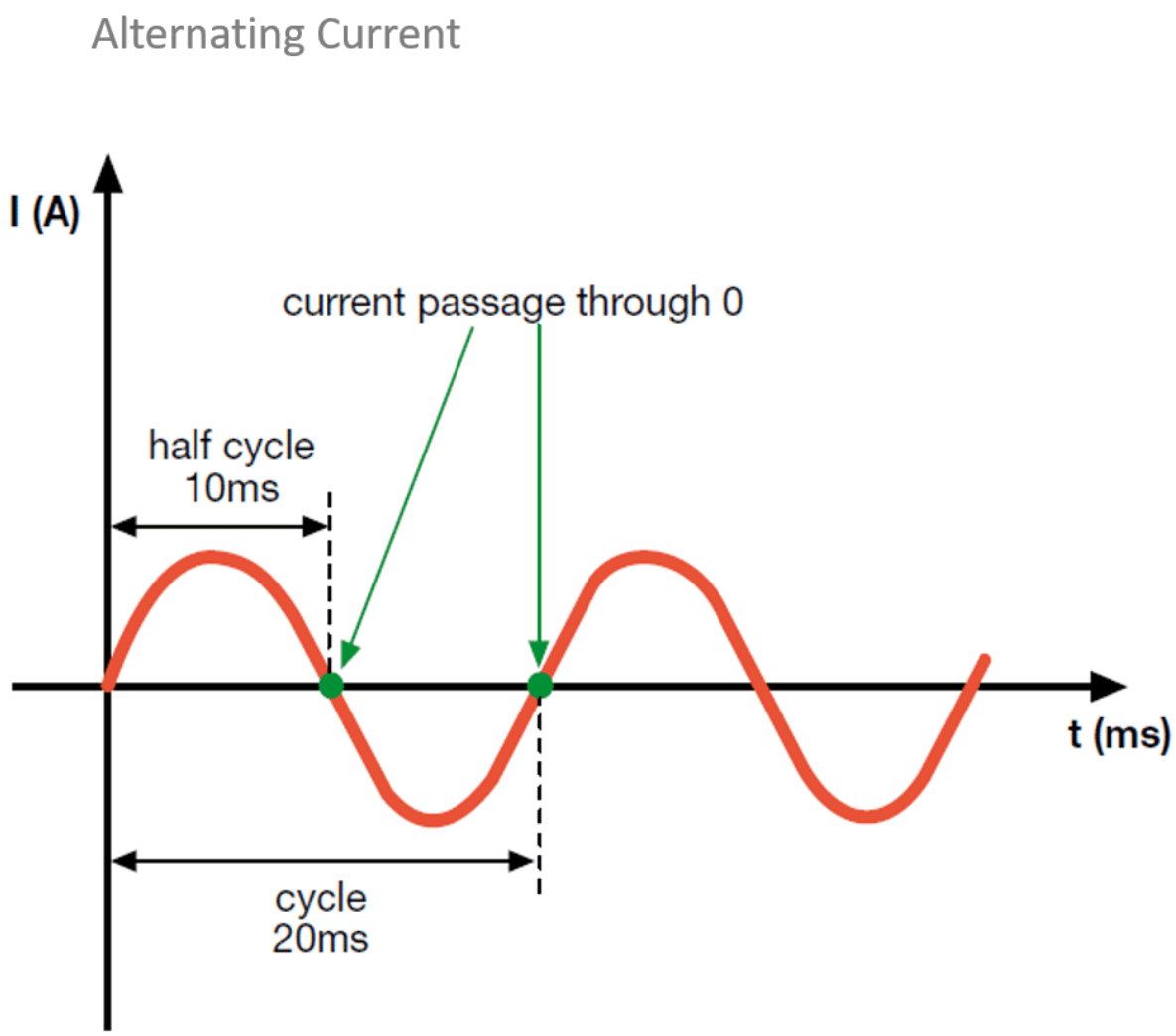
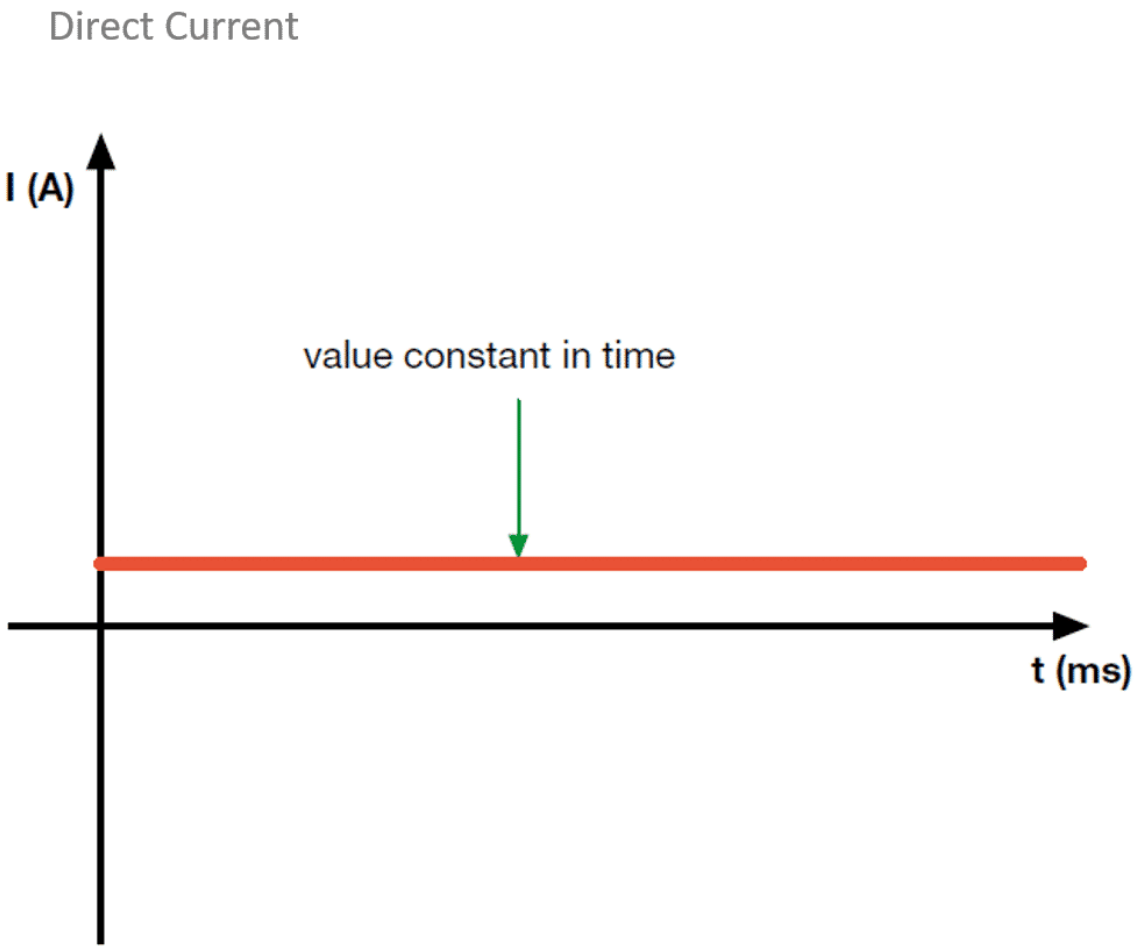
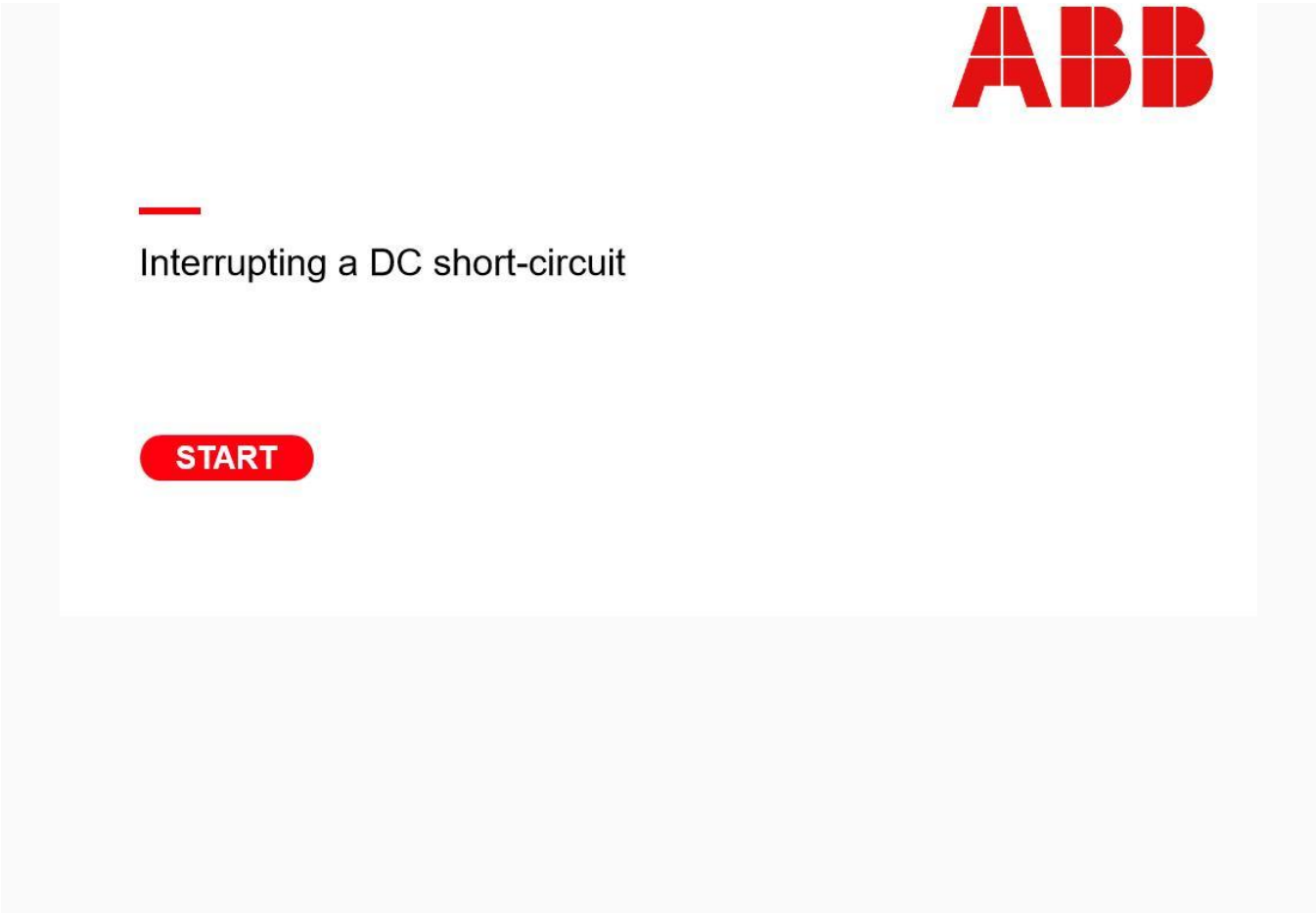
Why interrupting a fault is easier in AC than in DC?



Interrupting a fault in AC is easier due to the nature of the alternating current. As the figure shows, the current in AC crosses through zero at each half cycle. Therefore, the electric arc which is formed during the current interruption process is extinguished naturally the moment in which the current returns to zero.

The zero crossing does not occur with direct current and this makes the interruption process far more critical. Forced arc interruption would produce high transient recovery voltage with the ultimate destruction of the circuit breaker's contacts. To guarantee arc extinction, the current must decrease to null (forcing the current crossing through zero).





To force the current to zero, an arc voltage higher than the supply voltage must be created.

To summarize: in order to guarantee breaking of a short-circuit current in a DC system it is necessary to employ circuit breakers that can ensure:

- Rapid tripping with
- adequate breaking capacity

High fault current	limiting capacity
Overvoltage	reduction effect

SUBMIT

Complete the content above before moving on.

LV Circuit Breaker Technology

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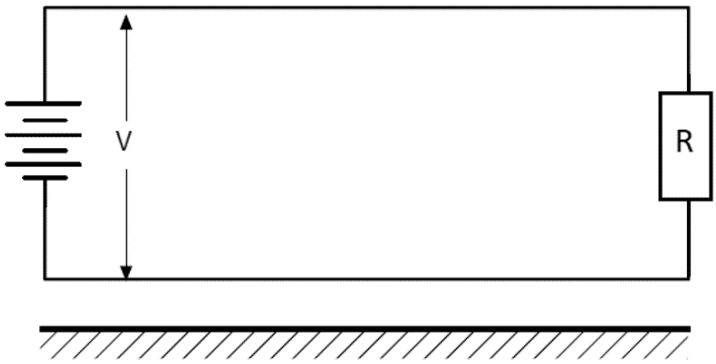
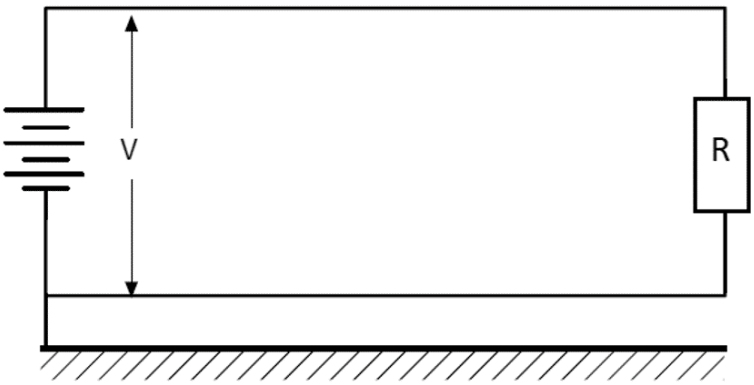
As previously explained, to break a short-circuit current in a DC system is necessary to create an arc voltage higher than the supply voltage to force the current to zero. In LV, a higher arc voltage is created by connecting the circuit breaker poles (contacts) in a suitable way. However, in order to define the pole connection, it is necessary to know the network grounding type. This information allows any possible fault condition to be evaluated and consequently the most suitable pole connection to be selected.

Types of DC Network

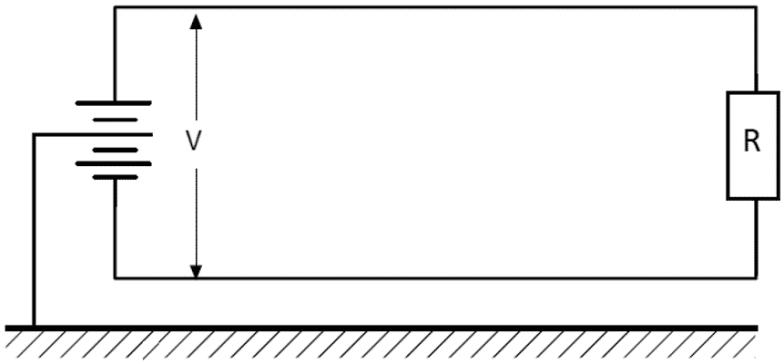
Each type of network presents a different possible fault condition that affects the connection of the circuit breaker poles. Below you can find the three types of the network grounding system.



Network insulated from ground



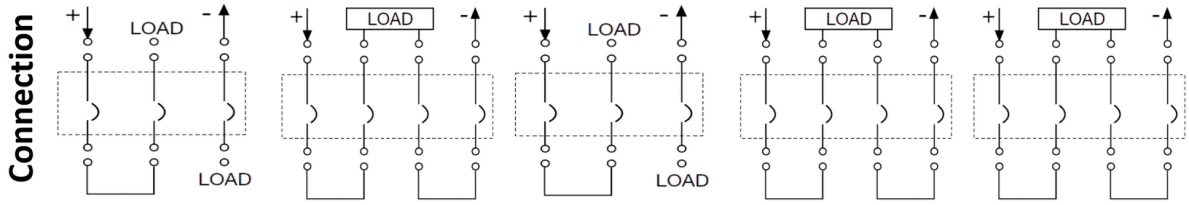
Network with one polarity grounded



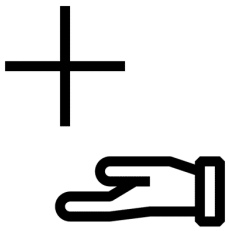
Network with the middle point of the supply source connected to ground

Poles Connection

According to the fault condition, the LV circuit breaker will have **3 or 4 poles connected in series**. In the figure below you have an example of the common poles connection for a network insulated from ground.

Vn	Vn ≤ 500		500 ≤ Vn ≤ 750		750 ≤ Vn ≤ 1000
Poles	3P	4P	3P	4P	4P
Connection					

The higher the number of poles opening the circuit, the higher is the breaking capacity of the circuit breaker.



Here is a tip for you, flip the card and check it out!

In the next module of this learning path, you will be able to check how and why to combine the pole configuration with the type of the network. Additionally, the fault types will be explained in details. Make sure you

CONTINUE

Lesson 5 of 8

MV Circuit Breaker Technology

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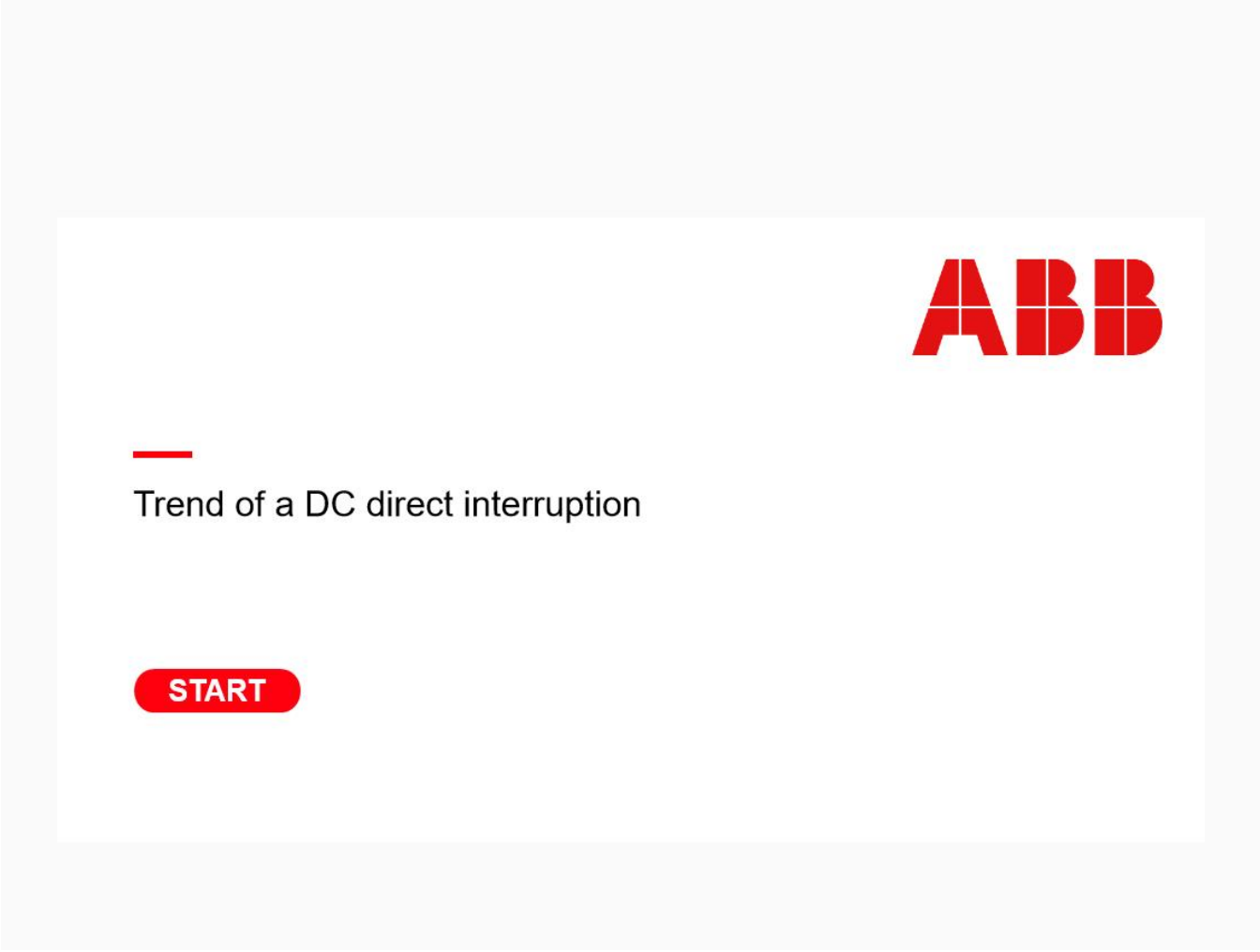
Interruptive Technology

As detailed in lesson 4, the interruptive technology in LV consists of 3 or 4 arc chambers (poles) connected in series. In MV it is used a **longer single arc chamber** instead. But remember, the goal is the same, to create an arc voltage higher than the supply voltage in order to force the current to zero.



The higher the arc chambers total length, the higher the arc voltage.

CONTINUE

ABB Offer

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Low Voltage

Automatic circuit breakers

For LV DC applications, ABB offers automatic circuit breakers. They carry out the protection function against overcurrents, and are divided into three families:

1

Miniature circuit breakers

For direct current applications, the miniature CB is available in three different series:

- S280 UC
- S800S UC
- S800 PV

2

Molded case circuit breakers

The molded case CB series SACE Tmax XT is divided into six basic sizes (XT1, XT2, XT3, XT4, XT5 and XT6), with an application field from 1.6A to 800A and current breaking capacities ranging from 16 kA to 100 kA (at 250VDC with two poles in series).

There are also the CB series SACE Tmax PV for protecting and isolating systems up to 1500V DC with rated current up to 1200A.

3

Air circuit breakers

The ACB series Emax is divided into four basic sizes (E2, E3, E4 and E6) with an application field from 800A (with E2) to 5000A (with E6) and current breaking capacities ranging from 35 kA to 100 kA (at 500VDC).

Medium Voltage

Air-insulated circuit breakers

For MV DC applications, ABB offers DCBreak family. They are suitable for use on trains (or rolling stock), tramways, subways and urban and regional light railways. These circuit breakers are also based on the direct current-suppression principle described in the lesson 5.

1

DCBreak: High-speed circuit breaker

DCBreak 915 & 1815

- Rated operational voltage: 900V | 1800V
- Rated current: 1500A
- Breaking capacity: 30 kA

CONTINUE

Support Material

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Do you want to know more about DC Breakers?

Download the Technical Application Paper No. 5 for LV and the No. 24 for MV applications.

PDF

Technical Application Papers No.5.pdf

1.2 MB

PDF

Technical Application Papers No. 24.pdf

9.1 MB

CONTINUE

Final Quiz

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Now that you have completed this module, it is time to take a short quiz. Get your notes and let’s see what you have learned!

Question

01/04

Which characteristics the circuit breaker must have in order to guarantee the interruption of a fault in a DC system?

Select three options.

- [ ] Rapid tripping with adequate breaking capacity
- [ ] High fault current limiting capacity
- [ ] Overvoltage reduction effect
- [ ] Slow tripping to do not form arc

Question

02/04

How a DC circuit breaker differs from an AC circuit breaker?

- A circuit breaker for DC system must have the poles in series to support higher arc voltage.
- A circuit breaker for DC system must have the poles in series to support higher current.
- A circuit breaker for DC system must have the poles in parallel to support higher arc voltage.

Question

03/04

Why a circuit breaker in a DC system is subjected to higher arc voltage?

- In AC circuit breakers, load current can be interrupted at natural sinusoidal zero crossings, which helps to minimize the electric arc produced. In a DC system, no such zero crossing exists, therefore the contact of a DC circuit breaker is exposed to substantially larger fault current during a circuit interruption.

- DC and AC circuit breakers are subjected to the same level of arc voltage during a circuit interruption. The difference is that in AC it is necessary to wait for the natural sinusoidal zero crossing to interrupt the circuit, while in DC no such zero crossing exists, therefore the interruption can be done instantly.

- In DC circuit breakers, load current can be interrupted at natural sinusoidal zero crossings, which maximize the electric arc produced. Therefore the contact of a DC circuit breaker is exposed to substantially higher fault current during a circuit interruption.

Question

04/04

What is the difference between a DC circuit breaker for LV and for MV?

- The interruptive technology: the LV circuit breaker has 3 or 4 shorter arc chambers connected in series, while the MV circuit breaker has a longer single arc chamber.
- The interruptive technology: the LV circuit breaker has a longer single arc chamber, while the MV circuit breaker has 3 or 4 shorter arc chambers connected in series.
- The interruptive technology: the LV circuit breaker has 3 or 4 shorter arc chambers connected in series, while the MV circuit breaker can have a longer single arc chamber or 4 shorter arc chambers connected in series.