

EEE4227: POWER SYSTEM PROTECTION TERM: MID-TERM



Lecture 05

Part 01-CB testing

Part 02-Auto re-closure system

Part 03-Interlocking & Neutral grounding

Part 04-Lightning arrester



Part 01- CB testing

Following is the classification of CB testing-

- ❖ Routine test
 - ❖ Operation tests
 - ❖ Millivolt drop tests
 - ❖ Power frequency voltage tests at manufacturer's premises
 - ❖ Power frequency voltage tests on site
- ❖ Type test
 - ❖ Short circuit tests
 - ❖ Making capacity tests
 - ❖ Breaking capacity tests
 - ❖ Short time current tests
 - ❖ Dielectric tests
 - ❖ Power frequency tests
 - ❖ Impulse voltage tests
 - ❖ Thermal tests
 - ❖ Mechanical tests



Routine test and type test

❖ Routine test:

Once a particular design is found satisfactory, a large number of similar circuit breakers are manufactured for marketing. Every piece of circuit breaker is then tested before putting into service. These tests are known as routine tests.

❖ Type test:

An equipment when designed to certain specification and is fabricated, needs testing for its performance. This type of testing is called type test.



Short circuit test

- ❖ **Making capacity tests** verify the ability of the CB to close on short circuit.
- ❖ **The breaking capacity tests** verify the ability of CB to clear short circuits.
- ❖ **The short time current tests** are applied to verify the ability of the circuit breaker to withstand **the temperature stress and electrodynamic forces**.



Dielectric test

- ❖ In case of an Indoor switchgear, CB should be carried out following test voltages for **1 min** between-
 - ❖ phases with the breaker closed
 - ❖ phases and earth with CB open
 - ❖ across the terminal with breaker open
- ❖ In case of an Outdoor switchgear, CB should be carried out standard **1/50 μ sec** wave between-
 - ❖ each pole and earth in turn with CB closed and remaining phases earthed
 - ❖ between all terminals on one side of the breaker and all other terminals earthed with the breaker open

In both the cases, CB should not flashover or puncture.
- ❖ The wet dielectric test is applied for outdoor switchgear. In this, the external insulation is sprayed for 2 mins while the rated service voltage is applied. The test service voltage is applied for 30mins during which no flashover should not occur.



Thermal test

- ❖ These tests are made to check the thermal behavior of the breaker.
- ❖ In this test, rated current is passed through all three phases of a switchgear for a long period of time to achieve the steady state condition.
- ❖ The temperature (measured using thermocouple) rise must not exceed 40°C when rated normal current is less than 80A and 50°C when 80A and above.



Mechanical test

- ❖ A CB must open and close at the correct speed and perform such operations without mechanical failure.
- ❖ The breaker mechanism is subjected to mechanical endurance type test involving repeated opening and closing of the breaker.
- ❖ B.S. 116:1952 requires 500 such operations without failure and with no adjustments of the mechanism.
- ❖ A resulting change in the material and dimensions of a particular component may considerably improve lifetime and efficiency of the mechanism.



End of part 01



Part 02- Auto reclosure

❖ Fault can be classified into three categories depending upon duration of fault-

- ❖ Transient fault
- ❖ Semi-permanent fault
- ❖ Permanent faulty

it is found that about 80% faults are transients faults, 12% are semi-permanent and 8% are permanent faults.



- ❖ The transient faults exist for a short time and these can be removed faster.
- ❖ If it is a semi-permanent fault, may be due to a twig falling or a bird spanning the power conductors, reclosing can be restored with some delay so that the cause of the fault can be burnt away during a time delay trip and the line can be reclosed to restore normal condition.
- ❖ However, for permanent fault, reclosing cannot be helpful as the line is to be taken out till the fault is cleared.

In case of transient and semi-permanent fault, auto reclosure can be a great relief as the line is not needed to be disconnect permanently.

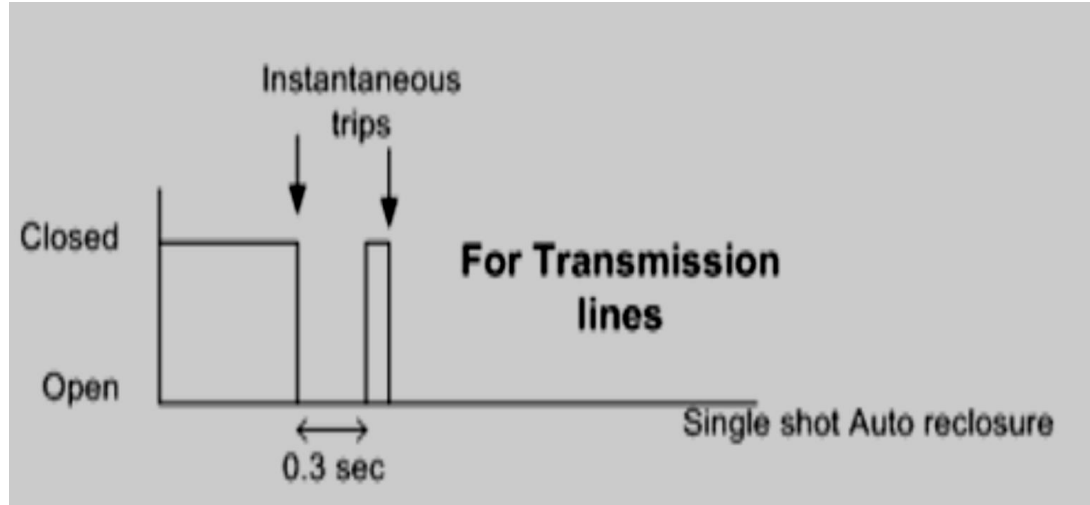


Auto reclosure

- ❖ What is auto reclosure??
 - ❖ Auto reclosure is a special type of CB in which a mechanism is provided so that the contacts of the CB will open when there is a fault on the system and will automatically try to close after a short delay.
- ❖ Auto reclosure can be of two types-
 - ❖ Single shot auto-reclosure
 - ❖ Three shot auto-reclosure

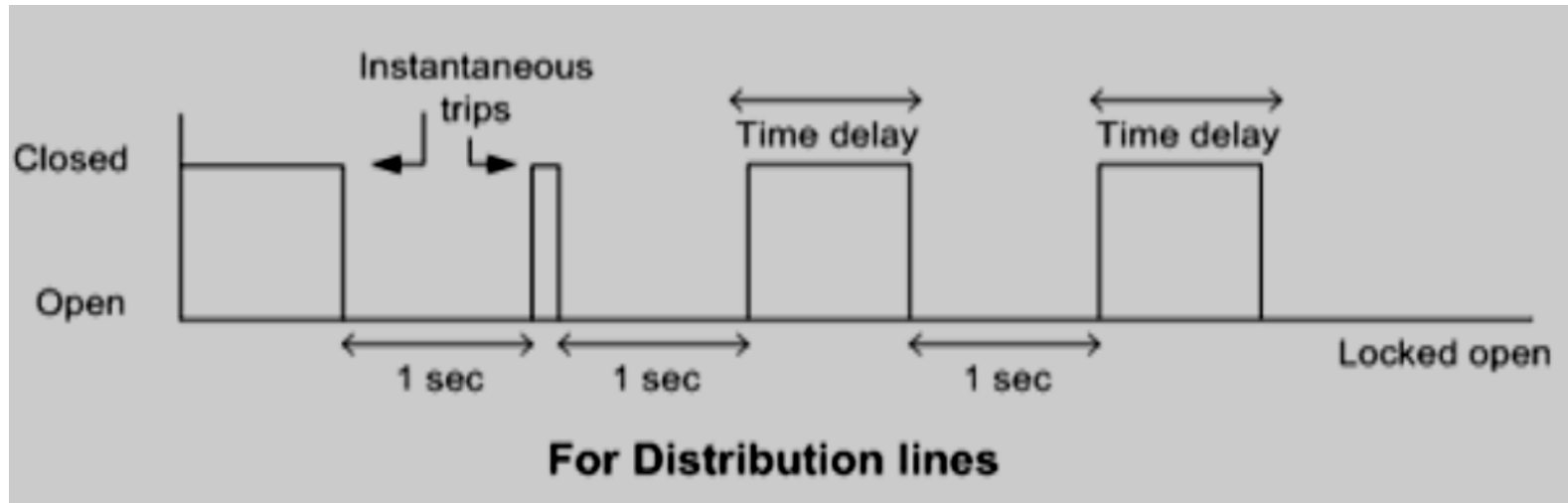
Single shot auto-reclosure

- ❖ Used in HV, EHV, UHV transmission line
- ❖ Dead time 0.3 sec. [A minimum of 0.2s must be allowed to enable the contact space to become deionized completely and 0.1 sec is taken as safety margin. Hence, a dead time of 0.3s can be taken as a safe re-closure time.]




Three shot auto-reclosure

- ❖ Used in distribution lines
- ❖ The supply continuity of service



A close-up, low-angle shot of a fish's scales, likely a salmon, showing a repeating pattern of overlapping, diamond-shaped scales. The scales are a silvery, iridescent color, reflecting light in a way that creates a shimmering effect. The pattern is dense and covers the left half of the frame, with the scales appearing to curve upwards and to the right.

End of part 02

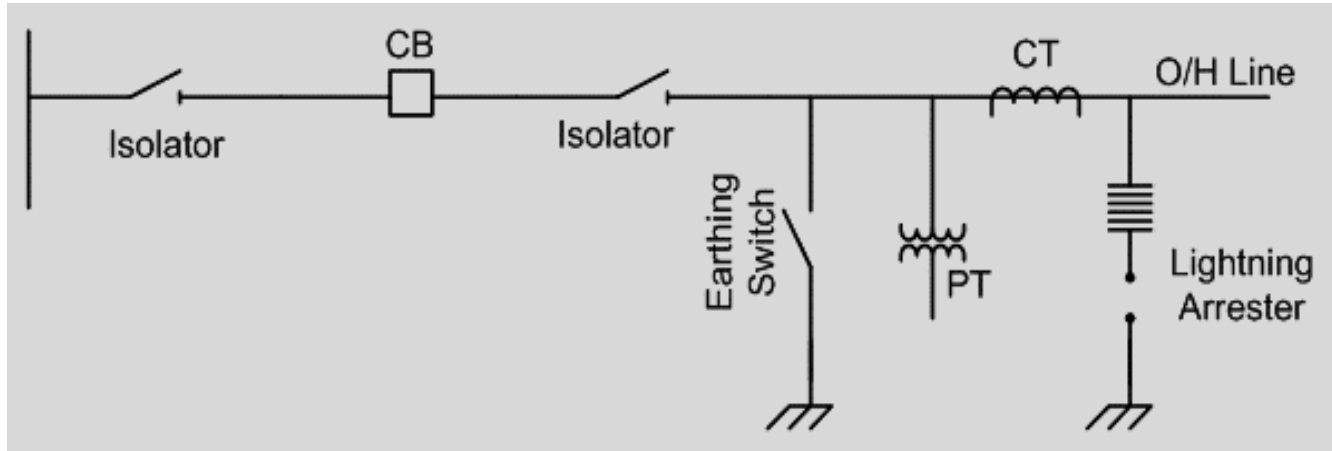


Part 03- Interlocking & neutral grounding

- ❖ What are interlockers?
 - ❖ Interlockers or Interlocking devices are those which enable the operation of the switching devices dependent upon the position and operation of other equipment.
- ❖ Why interlockers are necessary?
 - ❖ Interlockers are provided as a safety measure against erroneous operation of a switching device.

Interlockers

Layout of protecting devices for the protection of a circuit-



- ❖ Isolators and earthing switches are used for the safety of maintenance personnel.
- ❖ In order to discharge the trapped voltage of the line, earthing switch is used.

Interlockers

- ❖ Since isolators and earthing switches are no load disconnecting switches, so, **interlocking between isolator, CB and earthing switches are necessary.**
- ❖ Interlocking between isolator, CB and earthing switches demand a proper sequence of operation which is-

To break a contact:

- ❖ First CB is opened
- ❖ Isolator is opened
- ❖ Close earthing switch

To make a contact:

- ❖ Open earthing switch
- ❖ Close isolator
- ❖ Close CB



Neutral grounding

- ❖ The term “Earthing” or “Grounding” refers to connecting a conductor to ground.
- ❖ The neutral point of generator, transformer, rotating machines are connected to ground either *solid* or through R or L .
- ❖ This is done to provide ground fault protection as system voltage during earth fault depends on neutral grounding.



Neutral grounding

- ❖ Advantages of neutral grounding-
 - ❖ Neutral grounding eliminates “arching ground”
 - ❖ Stabilizes the neutral point. The voltages of healthy phases with respect to neutral are stabilized by neutral grounding.
 - ❖ Useful in discharging over-voltages due to lightning to earth.
 - ❖ Simplified design of earth fault protection.
 - ❖ Grounded systems required lower insulation level compared to ungrounded systems.



Neutral grounding

- ❖ Types of neutral grounding-

- ❖ Reactance grounding

- ❖ Preferred in OH and UG lines where charging current is high; used to neutralize charging current

- ❖ Resistive earthing

- ❖ Preferred where capacitance of network is low

- ❖ Solid earthing

- ❖ Preferred for circuits above 33kV

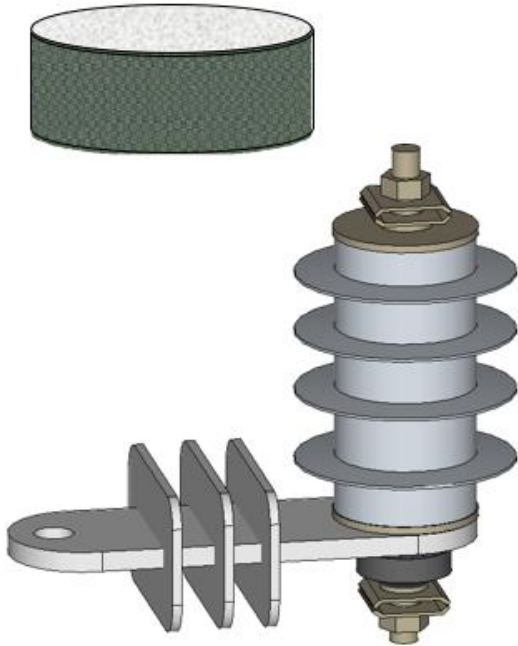
- ❖ Resonant earthing

- ❖ To neutralize power frequency capacitive current between line & earth

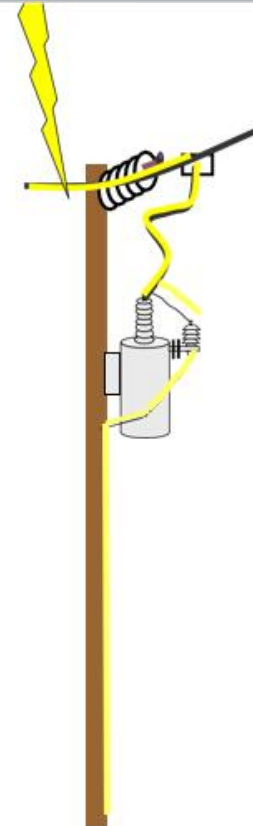
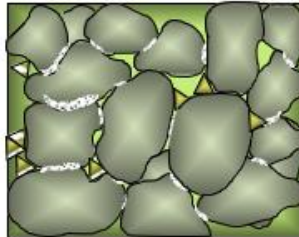
A close-up, low-angle shot of a fish's scales, likely a salmon, showing a dense, overlapping pattern of silvery, iridescent scales. The scales are arranged in a diagonal line from the bottom left towards the top right, creating a strong sense of movement and texture. The background is a soft, out-of-focus light blue.

End of part- 03

Part 04-Lightning arrester



What is a
Lightning
Arrester?



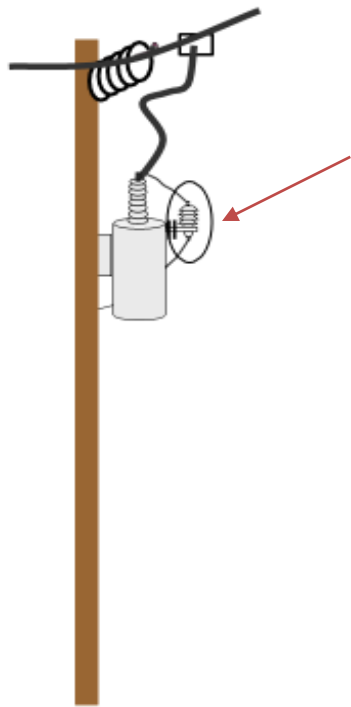


Lightning arrester

According to most definitions, a Lightning Arrester is....

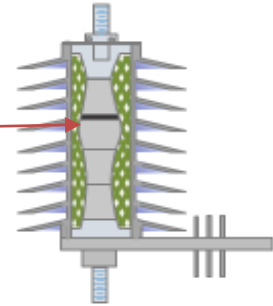
A Device Used on Power Systems above 1000V to Protect other Equipment from Lightning and Switching Surges

Lightning arrester

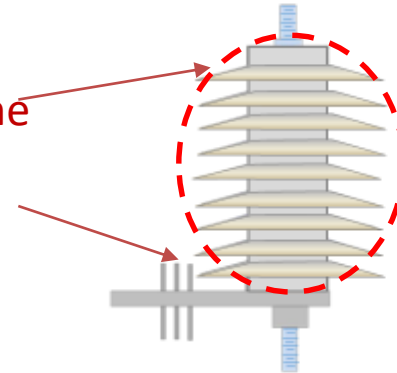


Lightning
arrester

Internal material of
the arrester

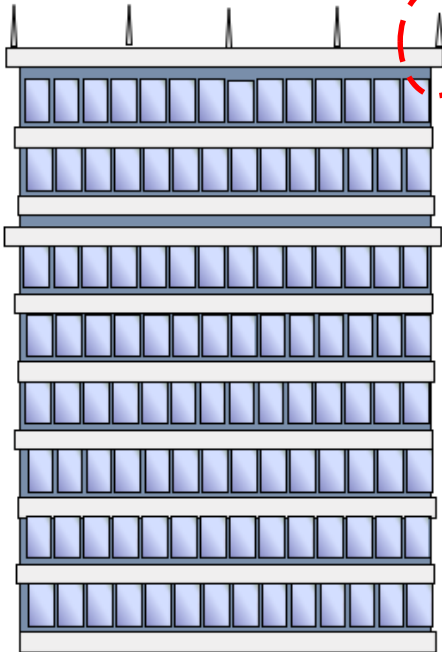


Bushing of the
arrester



Lightning arrester

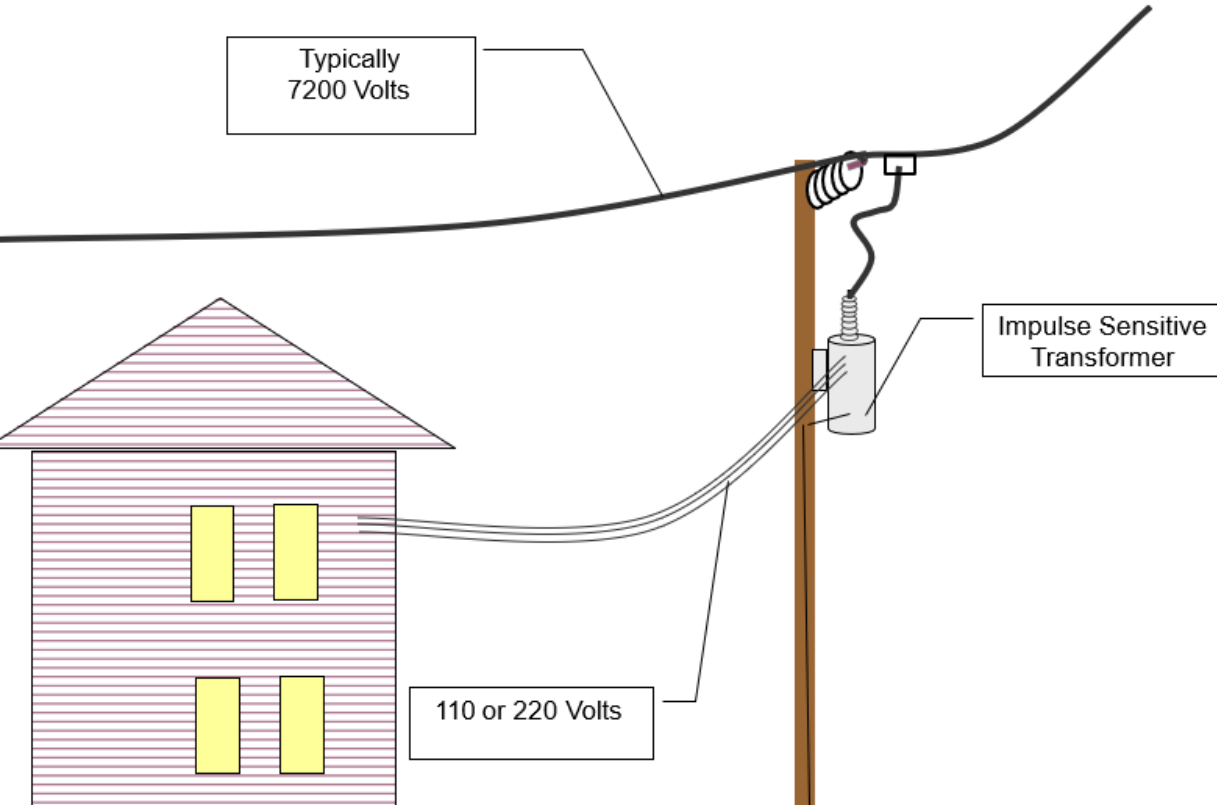
Lightning Rod



Although Lightning Rods are devices that divert lightning surges to ground, they are simple conductive terminals that are always at ground potential and are never energized.

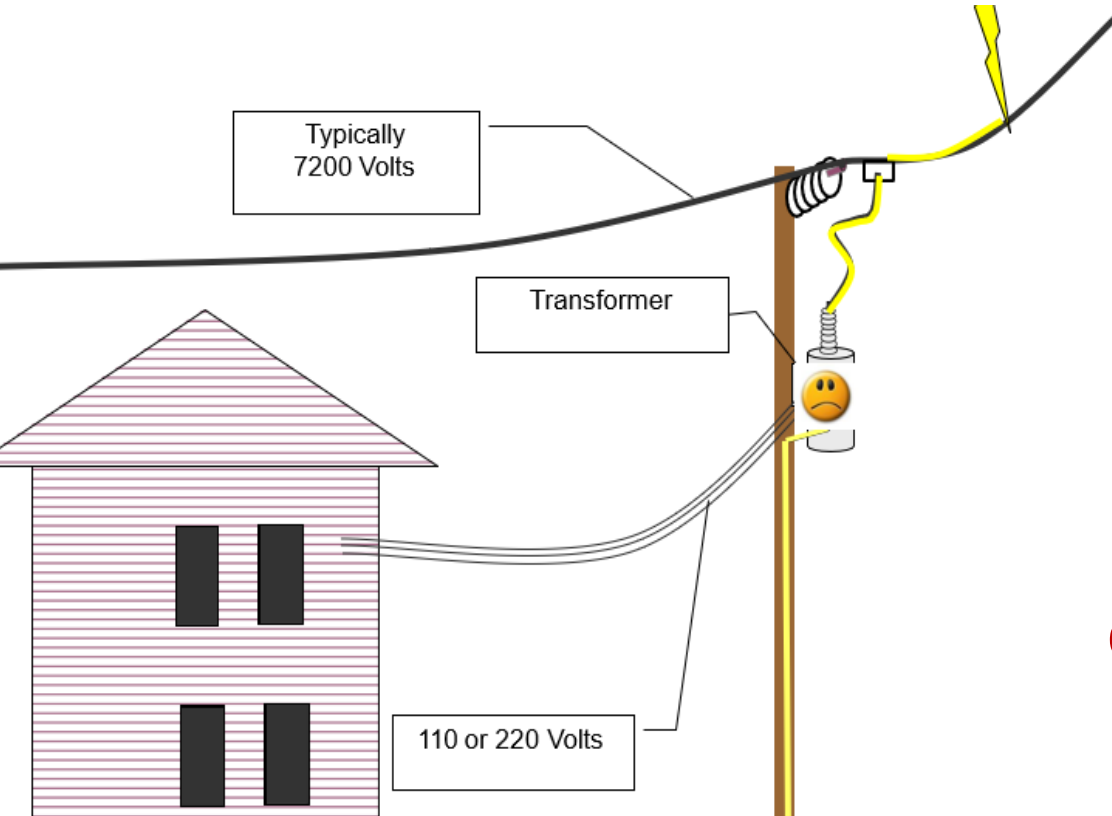
How do Lightning Arresters Protect Power Systems?

Lightning arrester



System
Without
Arrester

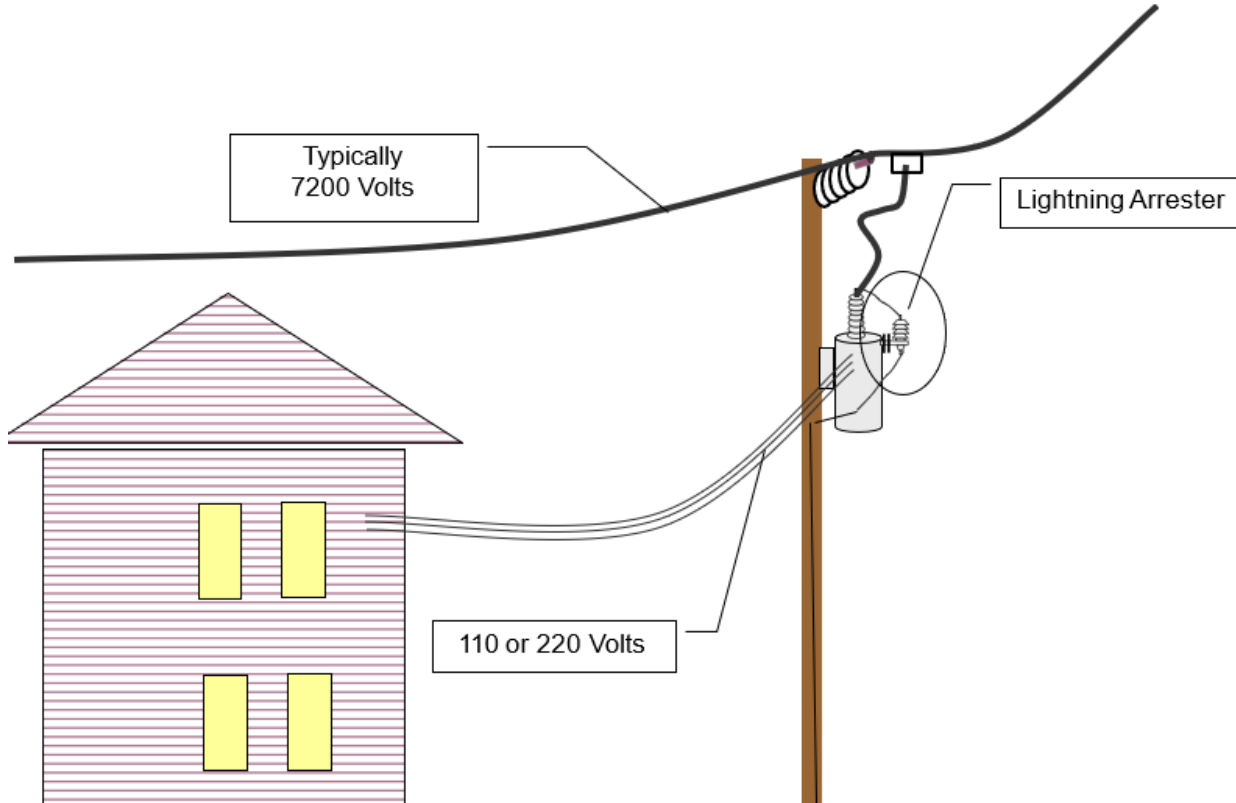
Lightning arrester



When
Lightning
strikes the
system

equipment is
damaged and the
lights go out

Lightning arrester



However a
System With
an arrester

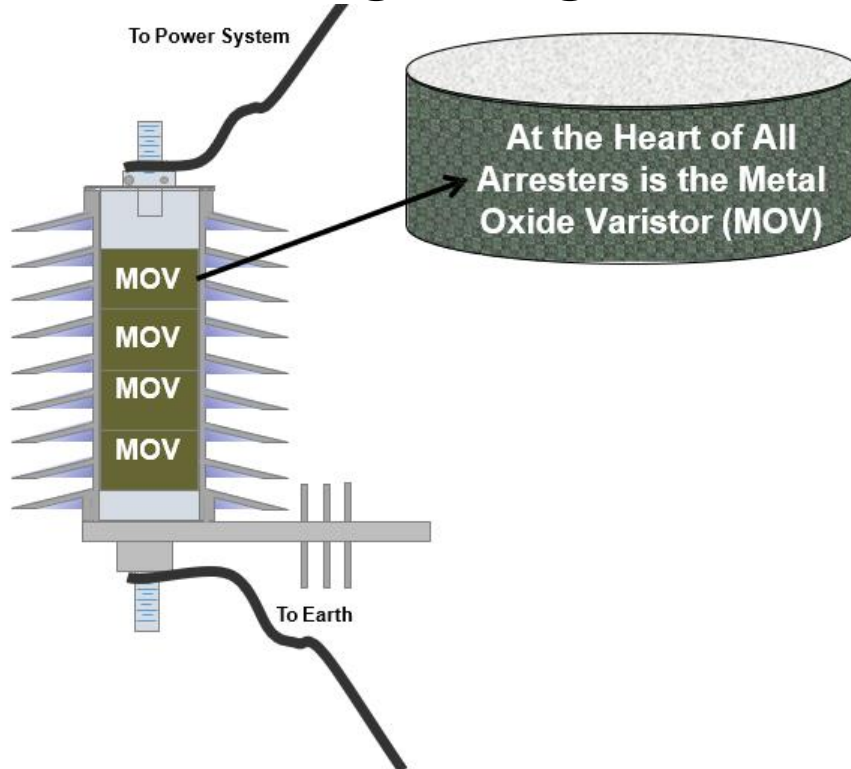


Lightning arrester

- ❖ What exactly does a lightning arrester do?
 - ❖ It Does not Absorb the Lightning
 - ❖ It Does not Stop the Lightning
 - ❖ It Does divert the Lightning to Ground
 - ❖ It Does Clamp (limit) the Voltage produced by the Lightning
 - ❖ It Only protects equipment electrically in parallel with it.

Lightning arrester

❖ How does a lightning arrester divert the lightning?



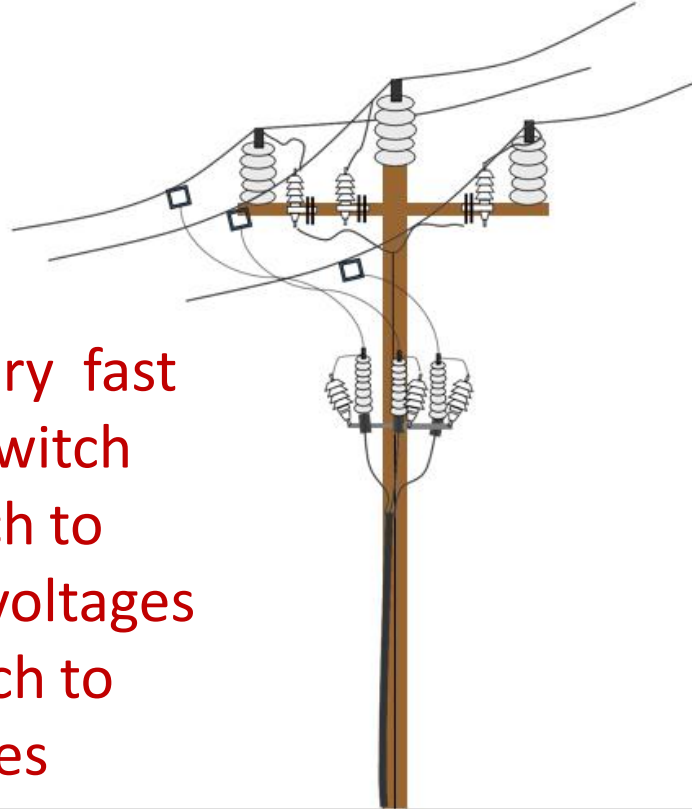
The MOV Disk is a Semiconductor that is sensitive to Voltage.

At normal Voltages the MOV disk is an insulator and will not conduct current.
But at higher voltages caused by lightning it becomes a conductor

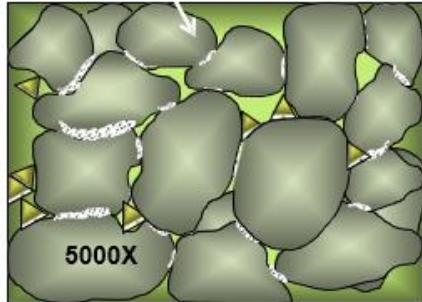
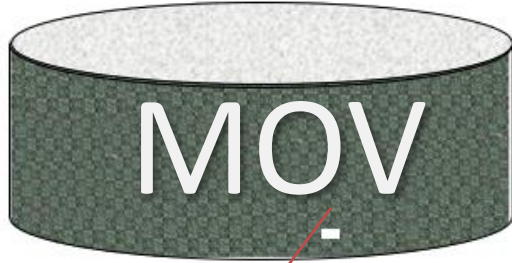
Lightning arrester



The MOV Disk is a very fast acting electronic switch
It is an open switch to standard system AC voltages
and a closed switch to lightning voltages



Lightning arrester

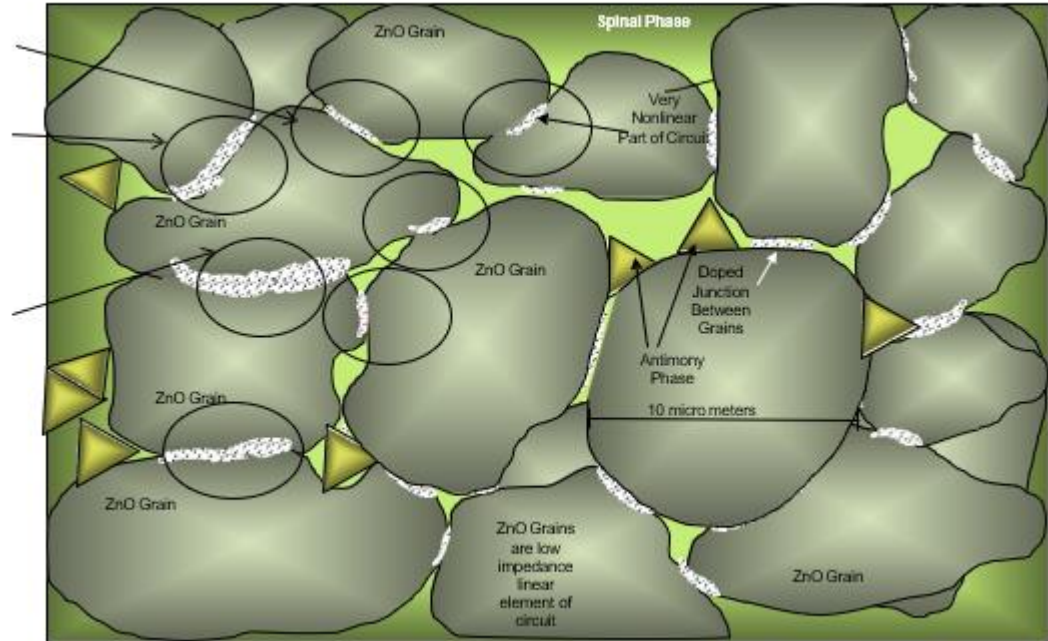


Each MOV Disk with a
35mm diameter and a
35mm height contains
about
28 Billion
MOV Grains

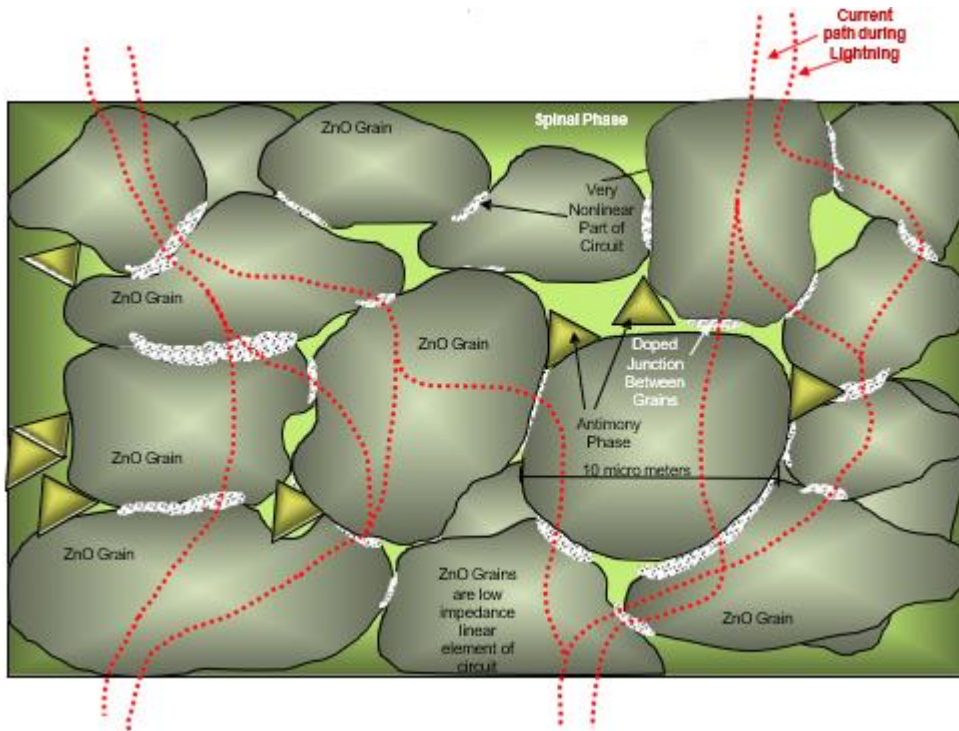
Lightning arrester

❖ The MOV Grains and their Junctions are the Electronic Switches that turn on and off in unison to divert the lightning around the equipment.

- ❖ The Switches are at the junctions between the grains
- ❖ These are voltage sensitive switches that switch on at about 3 volts
- ❖ If there are 1000 junctions from top to bottom of a disk, it will have a total turn on voltage of about 3000 volts



Lightning arrester



- ❖ A lightning arrester is essentially a collection of billions of microscopic junctions of Metal Oxide Grains that turn on and off in microseconds to form a current path from the top terminal to the ground terminal of the arrester.



Lightning arrester

- ❖ So there is it. A Lightning Arrester is a device, used on power systems, that contains billions of electronic switches that divert lightning currents around sensitive equipment and saves them from damage.



End of part 04

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- Reference-
 - Topic 2.10, 2.12, 2.13, 2.13, 10.2, 10.3/ Chapter 02/ Switchgear protection and power systems/Sunil S. Rao

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