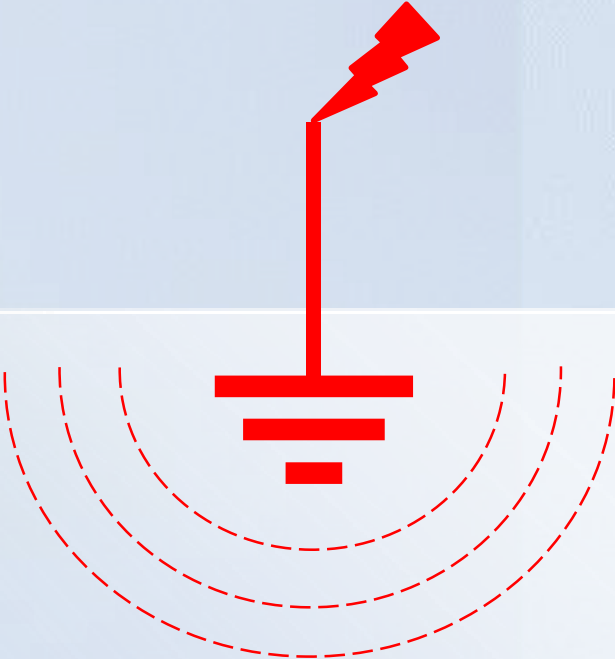


ELECTRIC POWER SYSTEM GROUNDING

By
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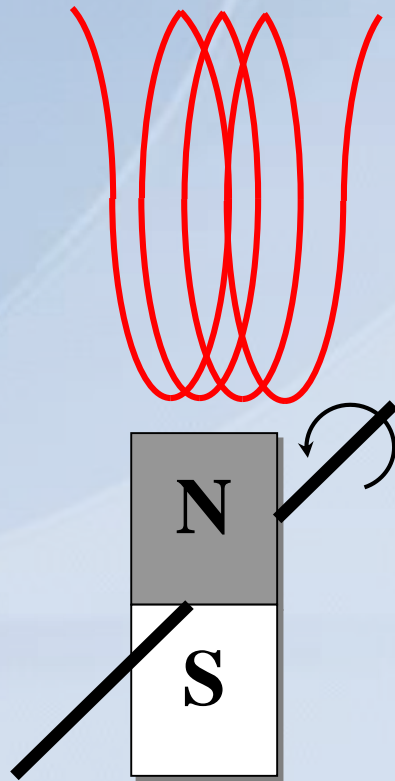
Electric Power System Grounding

Presentation Outline

- **3-Phase Power Systems**
- **Reasons for Grounding and Bonding**
- **Substation, Transmission, and Distribution Grounding**
- **Power Faults and Lightning Strikes**
- **Fault current distribution**
- **Ground Potential Rise (GPR)**
- **Touch and Step Potentials**
- **Safety**

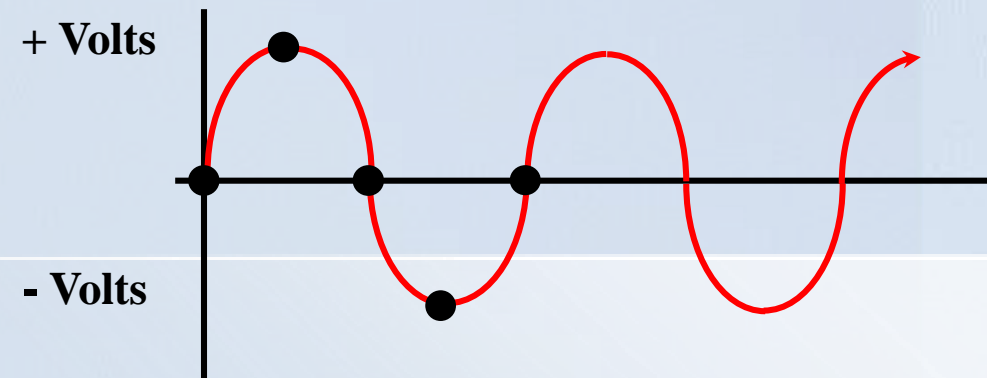
3-Phase Power Systems

Single Phase Generation



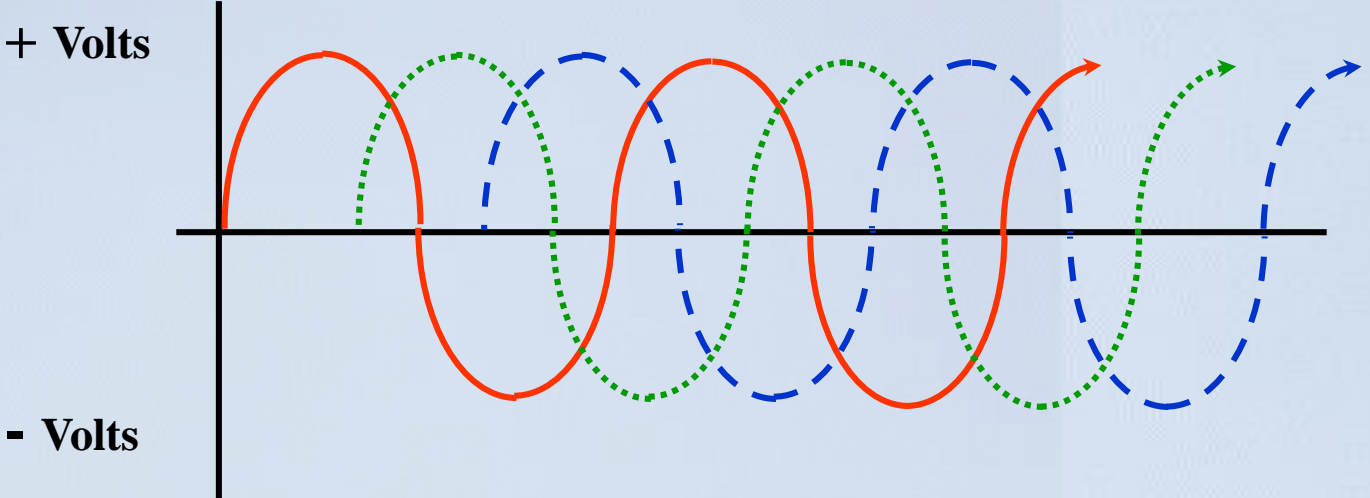
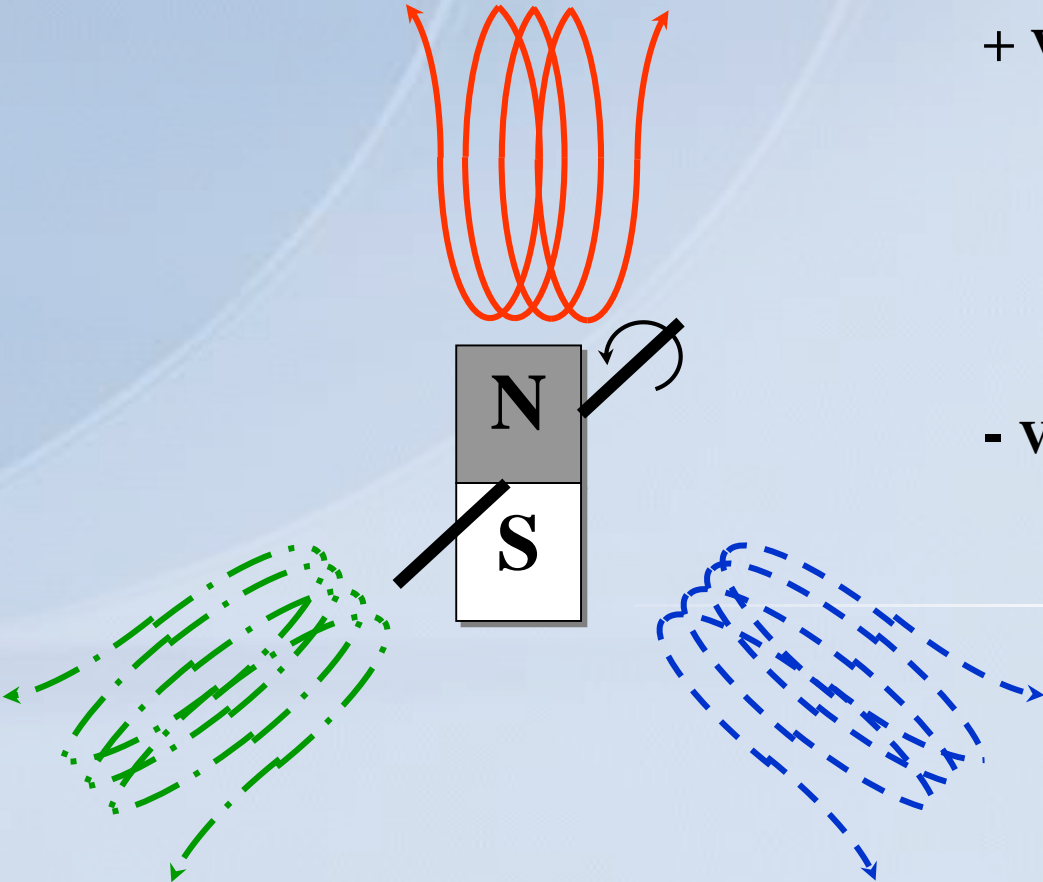
Faraday's Law:

Voltage is produced on any conductor in a changing magnetic field!



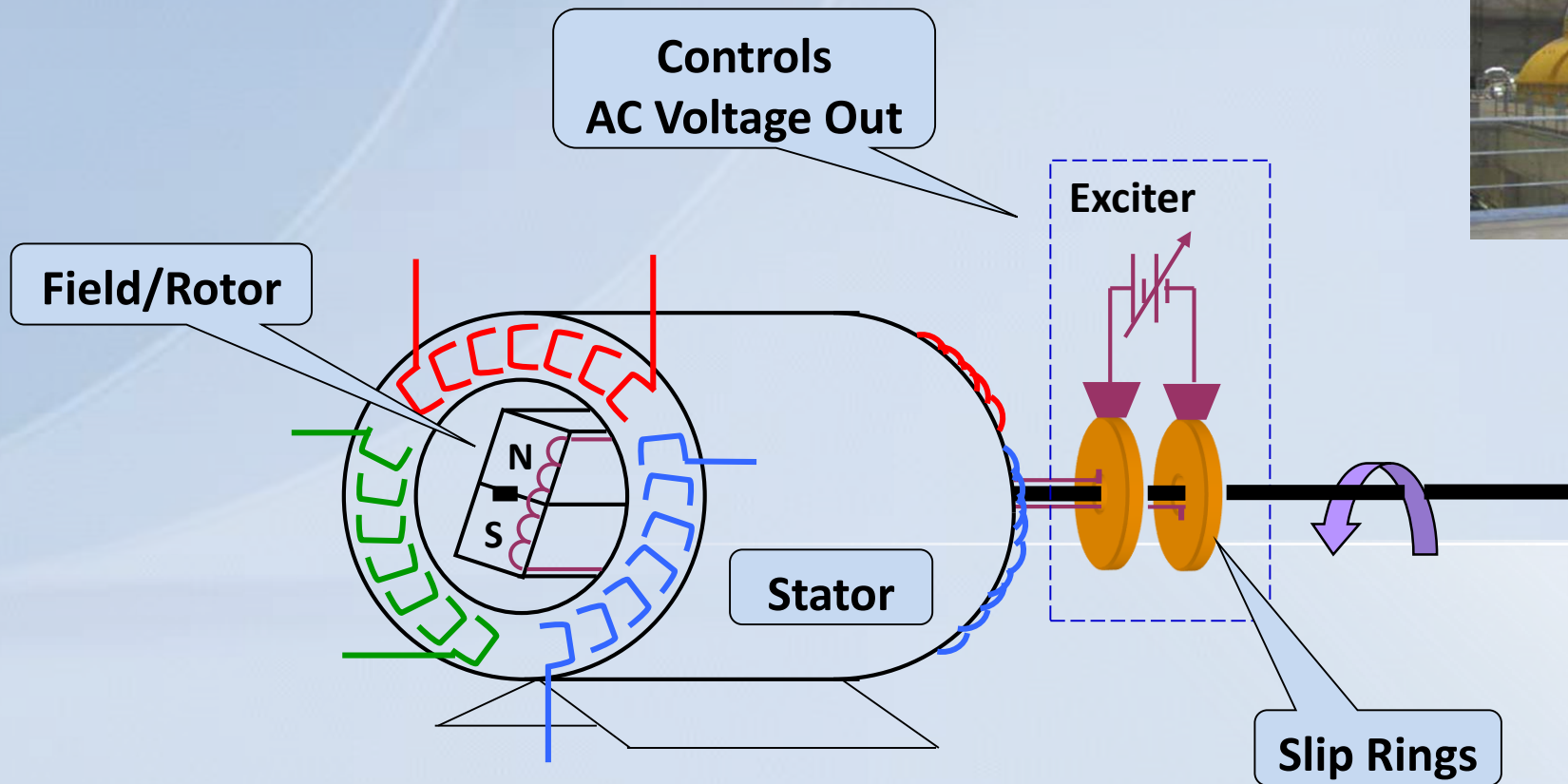
3-Phase Power Systems

Three Phase Generation



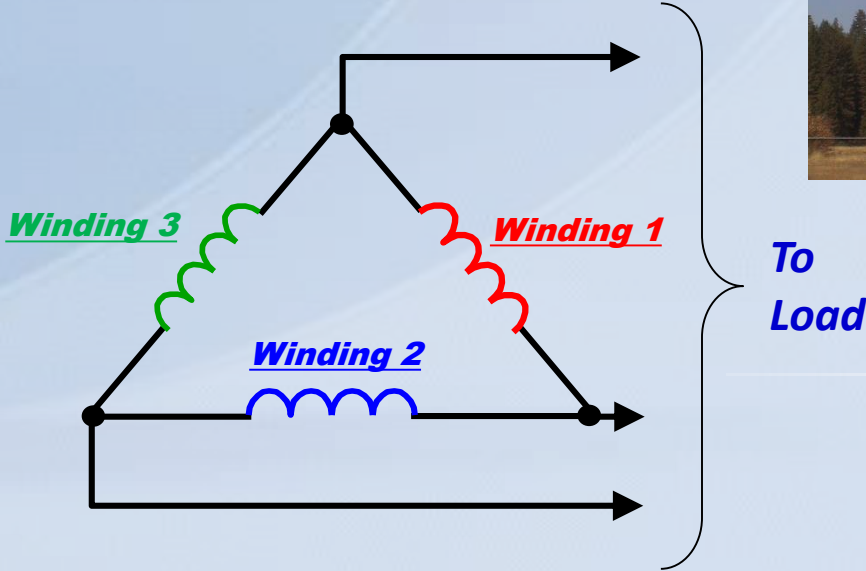
3-Phase Generator

3-Phase AC Generator

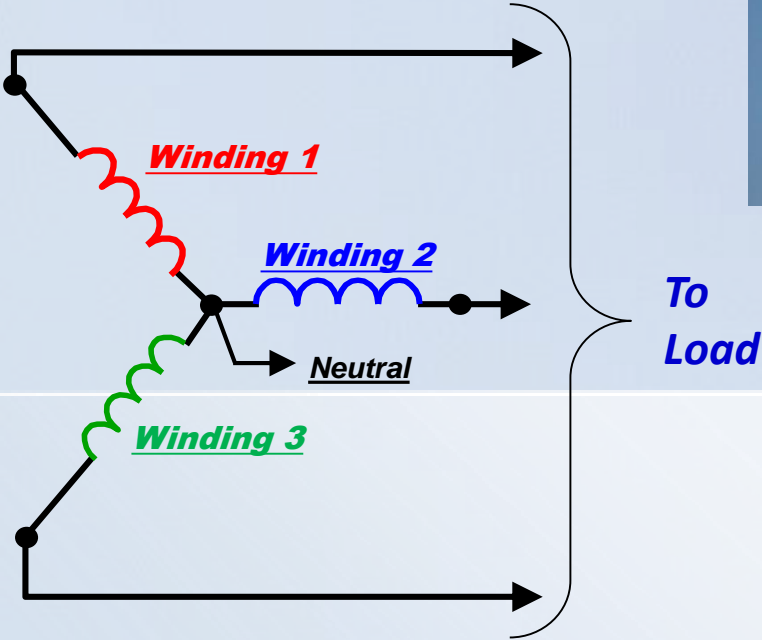


3-Phase Power Systems

Symmetrical Connections



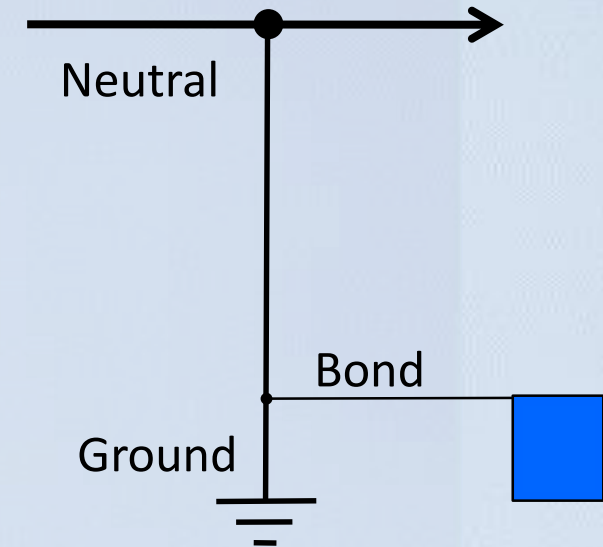
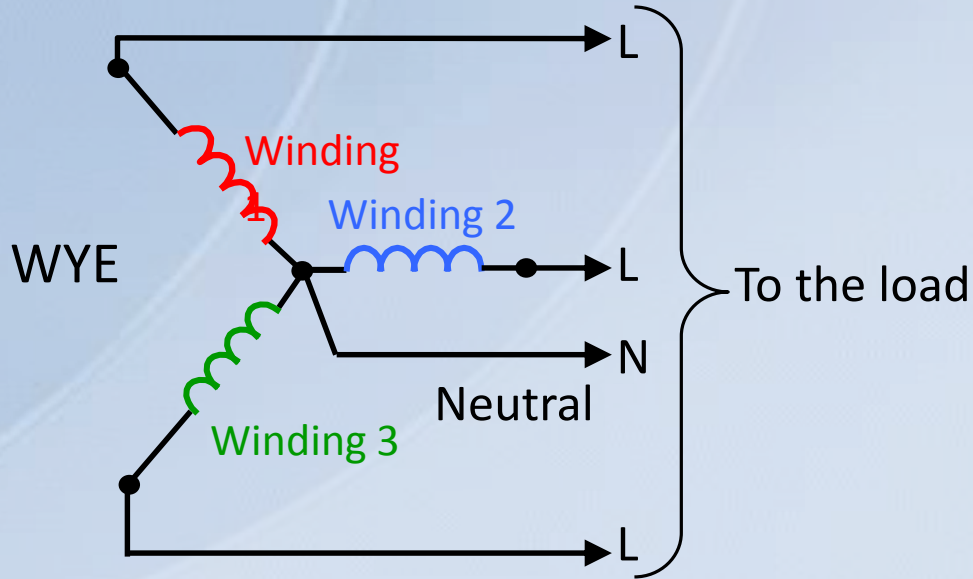
Delta



WYE

3-Phase Power Systems

Neutral vs. Ground vs. Bond



- Grounding: the neutral is connected to earth via ground rods, grids, or conductors. Unbalanced neutral currents flow through the earth connection.

- Bonding: electrical connections between equipment and grounded conductors to provide equipotential during faults.

3-Phase Power Systems

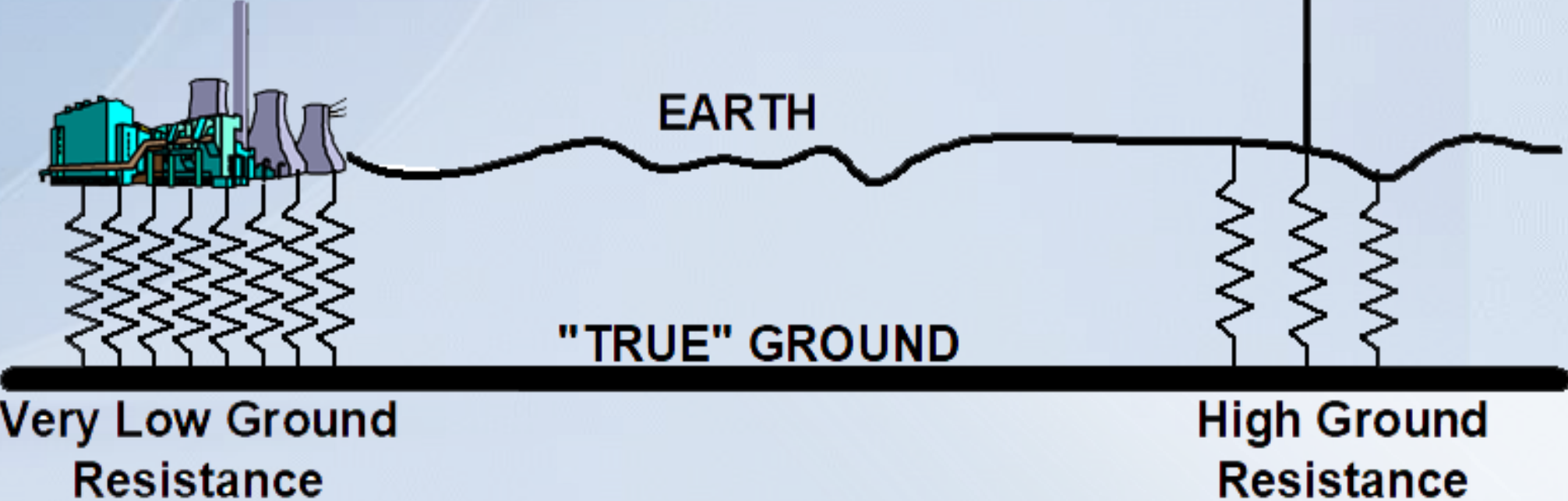
Reasons for Grounding and Bonding

- Control power fault and Lightning strike currents
- Protect equipment and trip energizing equipment
- Equipotential Grounding
- Effects of Ground Potential Rise
- Touch and Step Potentials
- Detect and minimize unbalanced currents

3-Phase Power Systems

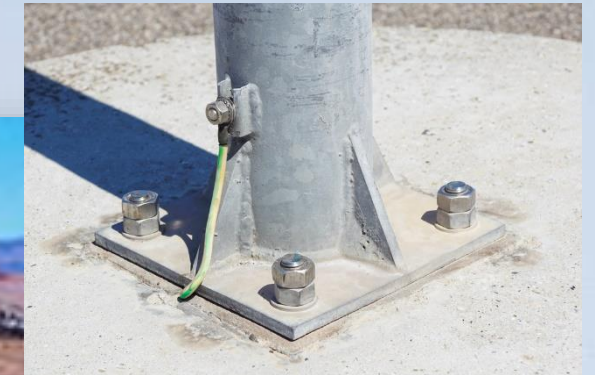
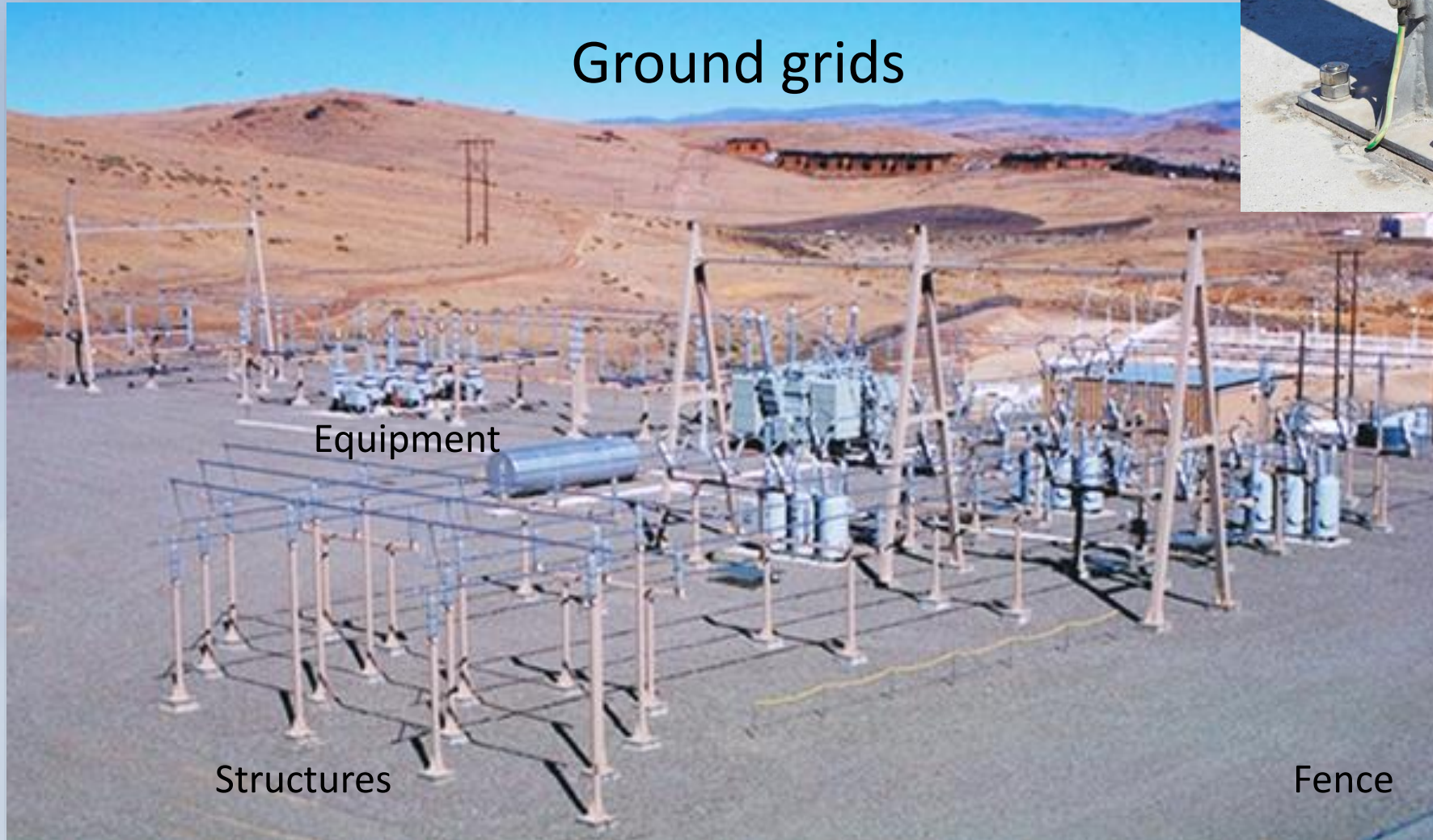
System Grounding

ENERGY SOURCES



3-Phase Power Systems

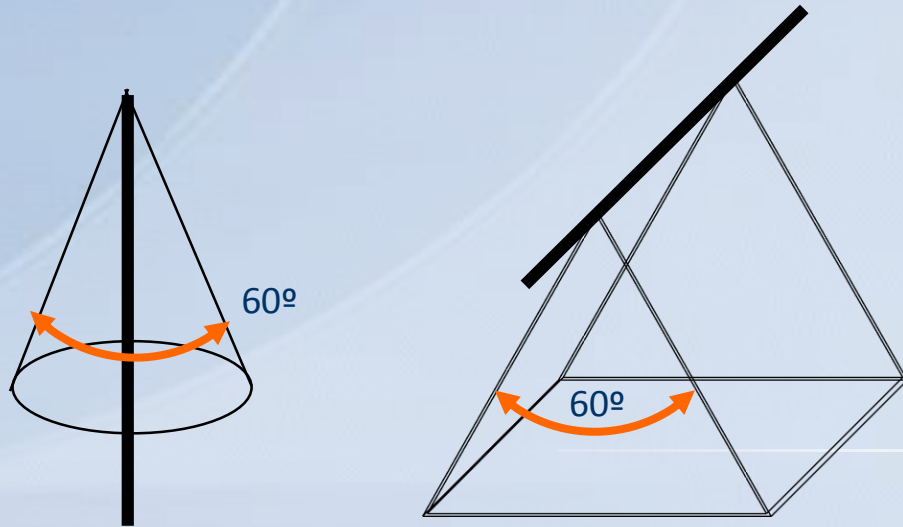
Substation Grounding



3-Phase Power Systems

Transmission Line Shielding and Grounding

Lightning Protection through Grounding



Rod

Line

60° shield angle is typical

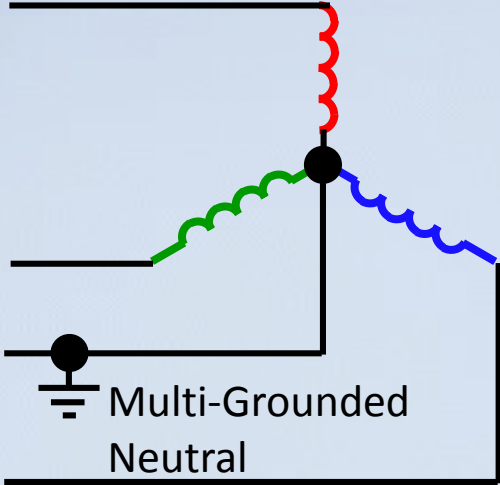
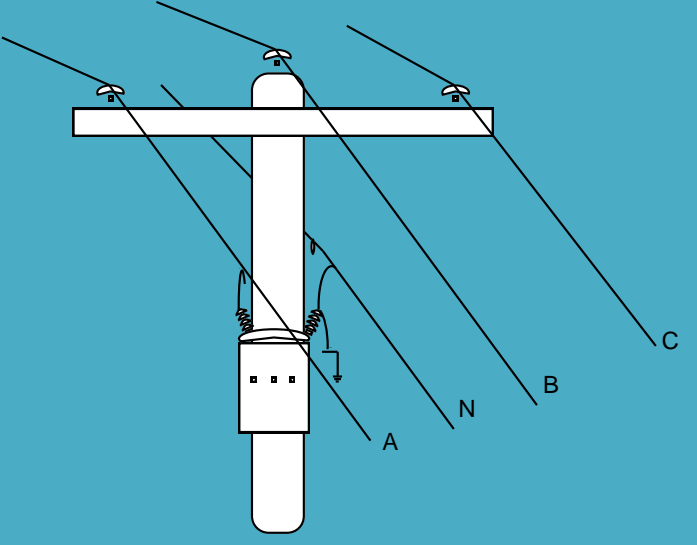
Shield Wires and
Optical Ground Wires



3-Phase Power Systems

Distribution Lines: Wye Configuration

Multi-grounded Neutral: At least four times per mile per the National Electric Safety Code



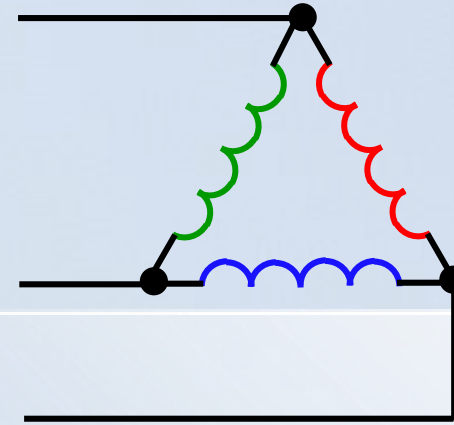
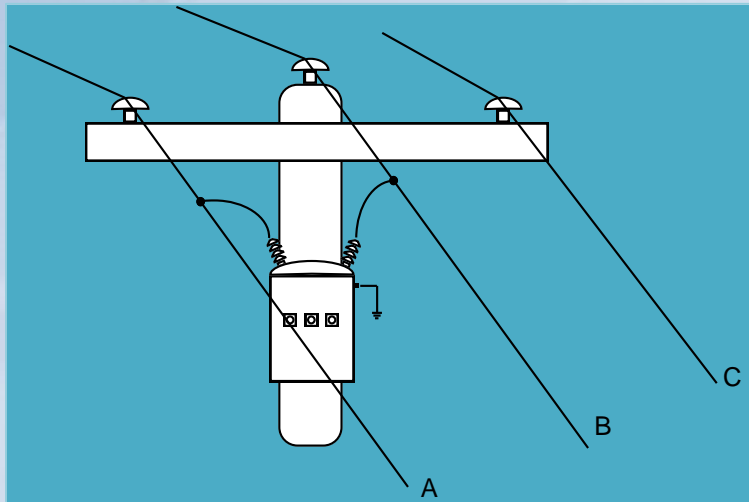
Grounded neutral



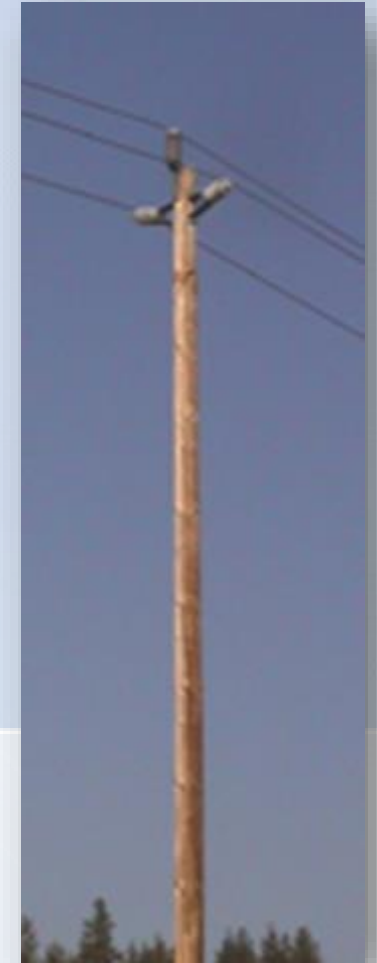
3-Phase Power Systems

Distribution Lines: Delta Configuration

Delta three-phase distribution lines use three wires, no neutral. Transformer tanks and lightning arresters are connected to ground rods at each pole.



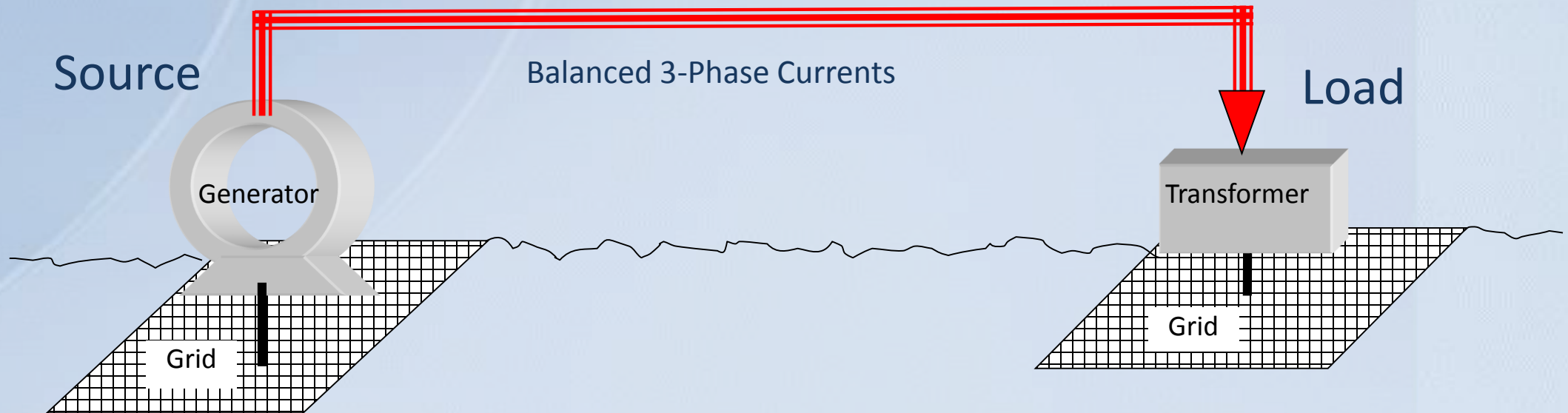
No grounded neutral!



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3-Phase Power Systems

Balanced Conditions

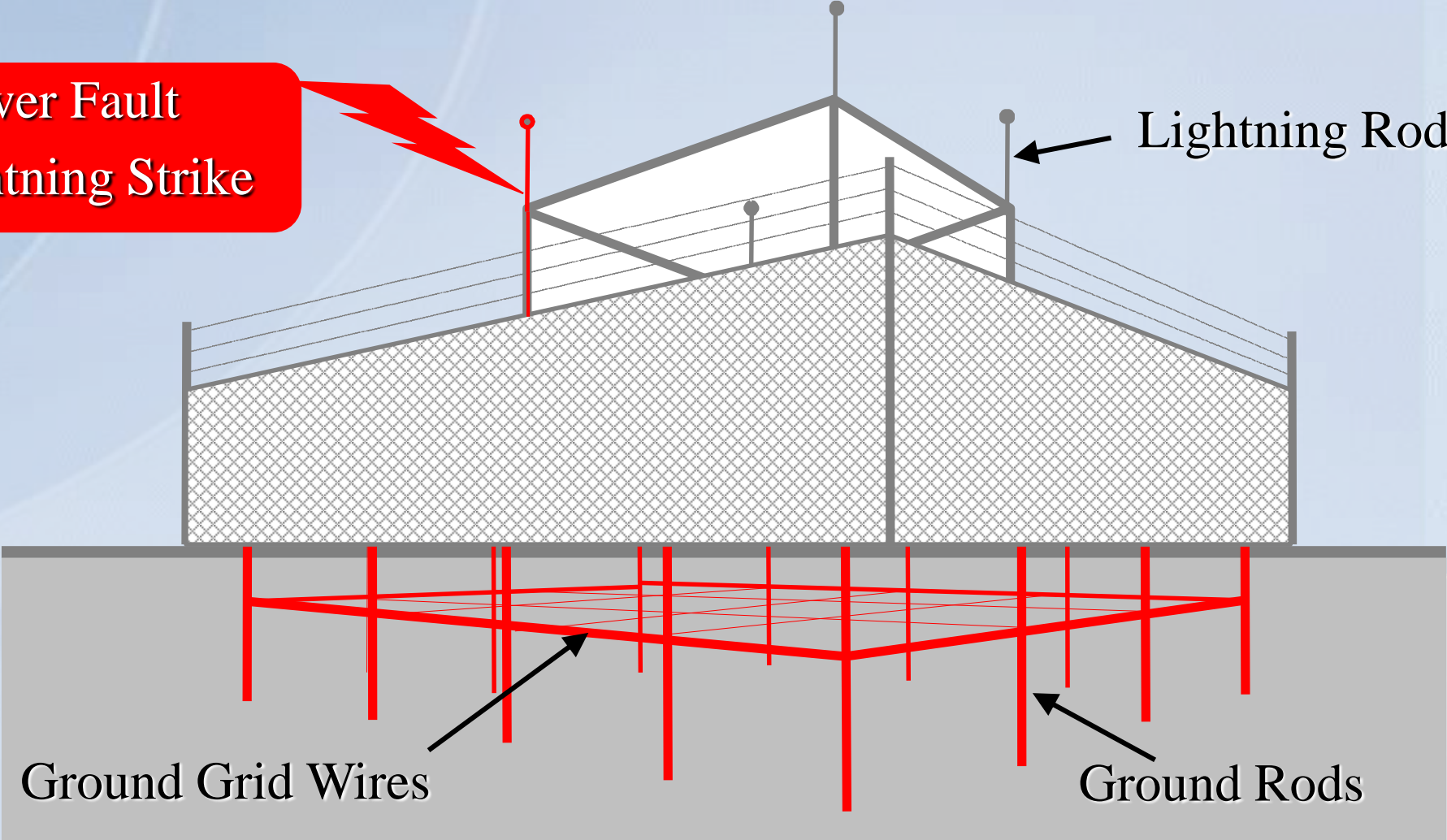


NO Earth Return Current!

Power System Fault

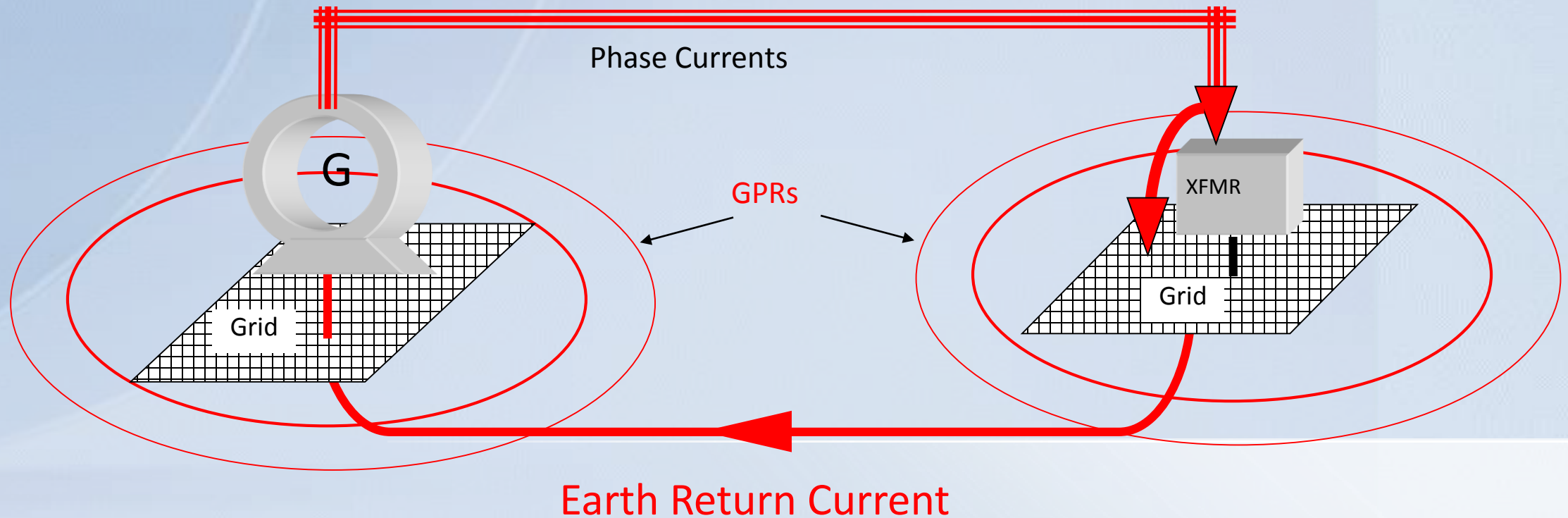
Substation Fault

Power Fault
or Lightning Strike



Power System Fault

Ground Potential Rise (GPR) – unbalanced current

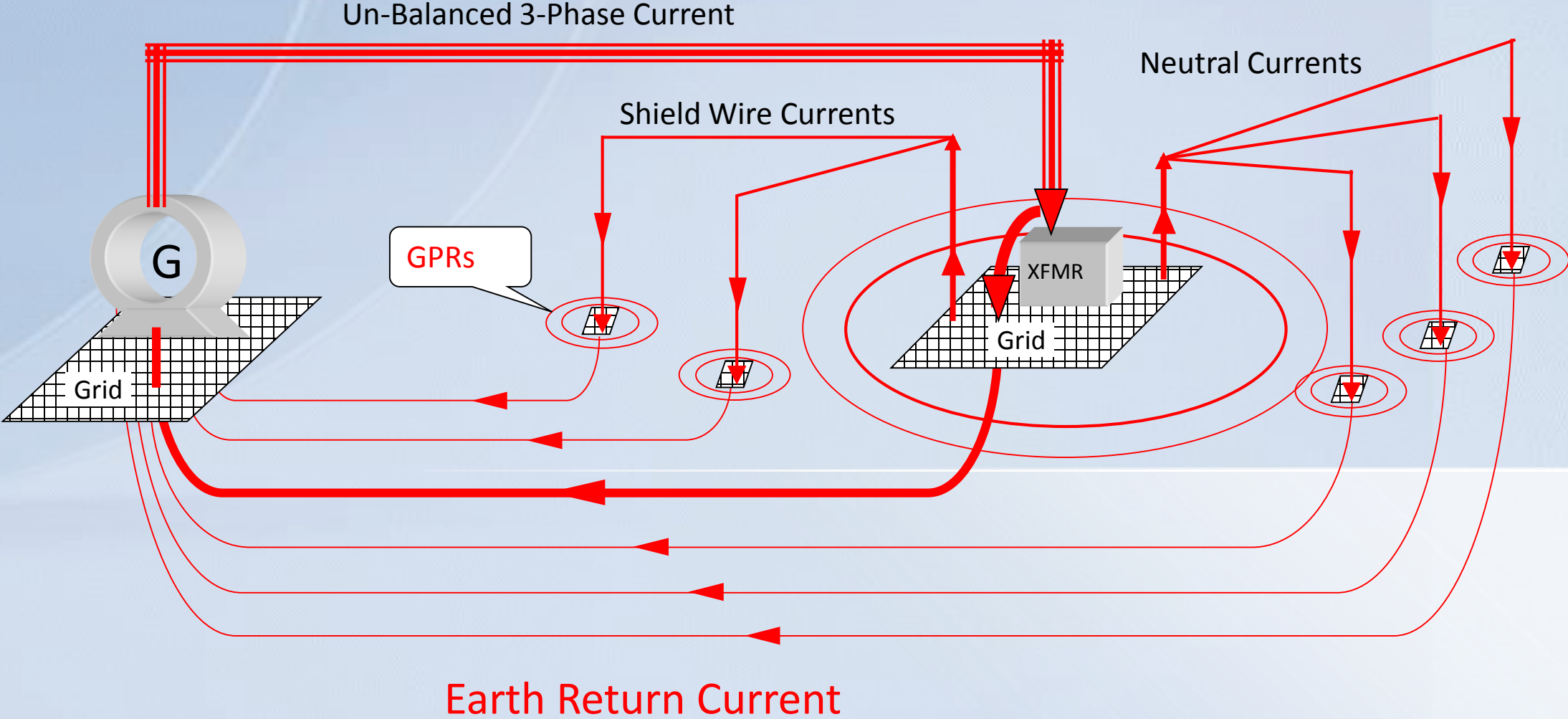


Assumptions

- Homogenous Soil (i.e., round contours)
- Power Fault at substation transformer bushing

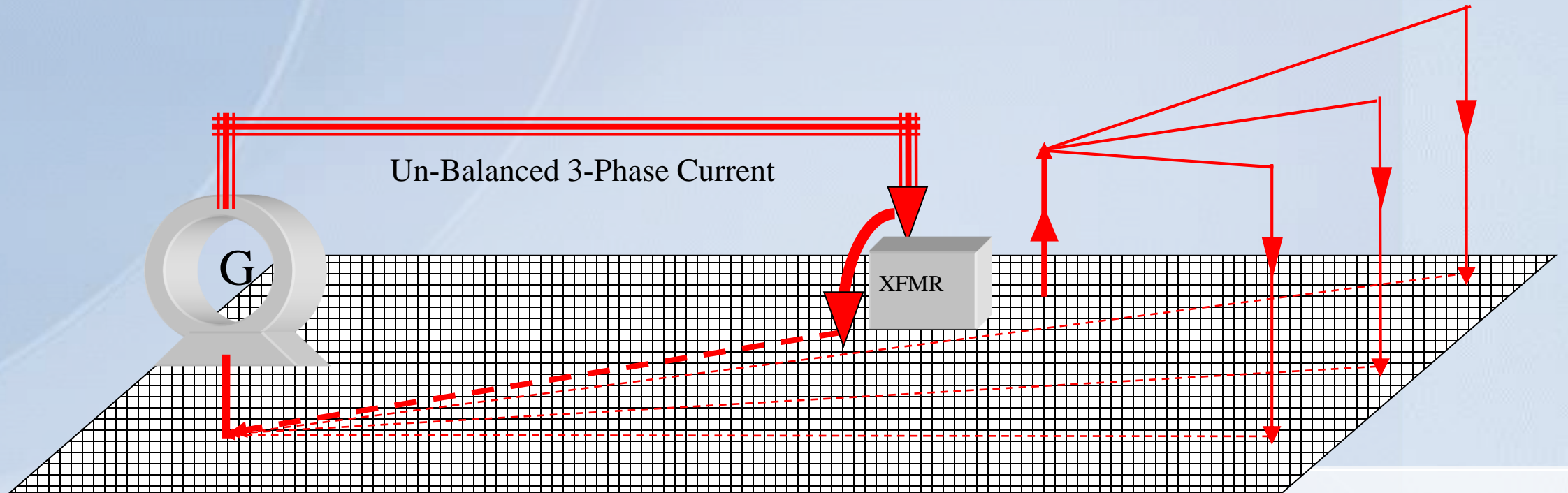
Power System Fault

Multiple Ground Paths and GPR's



Power System Fault

Metropolitan Grids



NO Earth Return Currents!!!

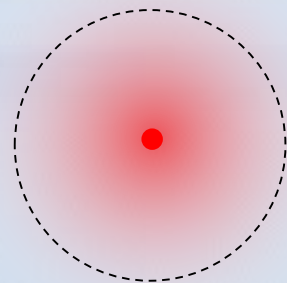
NO GPR!!!

Current flow through grid: YES

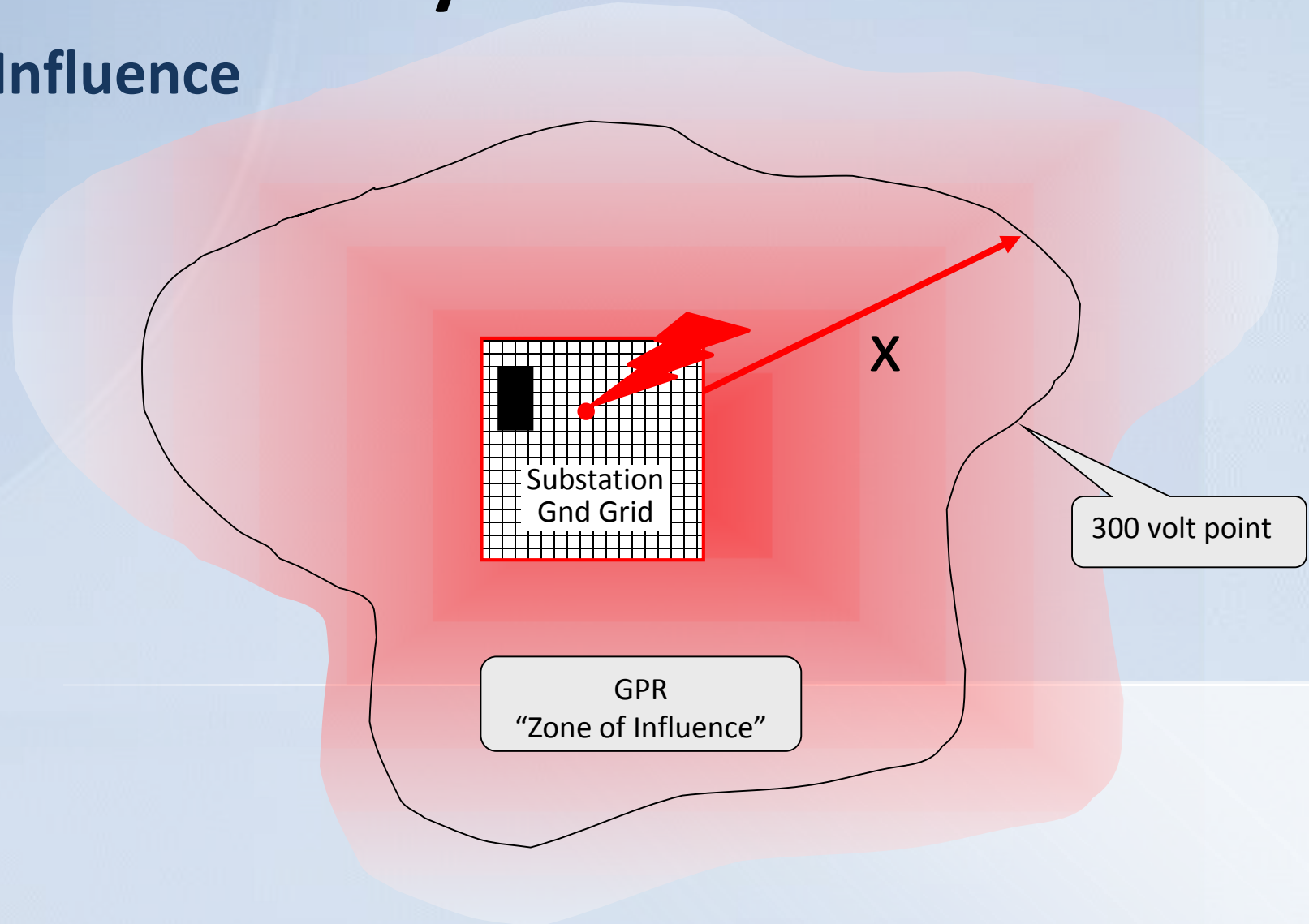
Voltage drop on grid: YES

Power System Fault

GPR - Zone of Influence



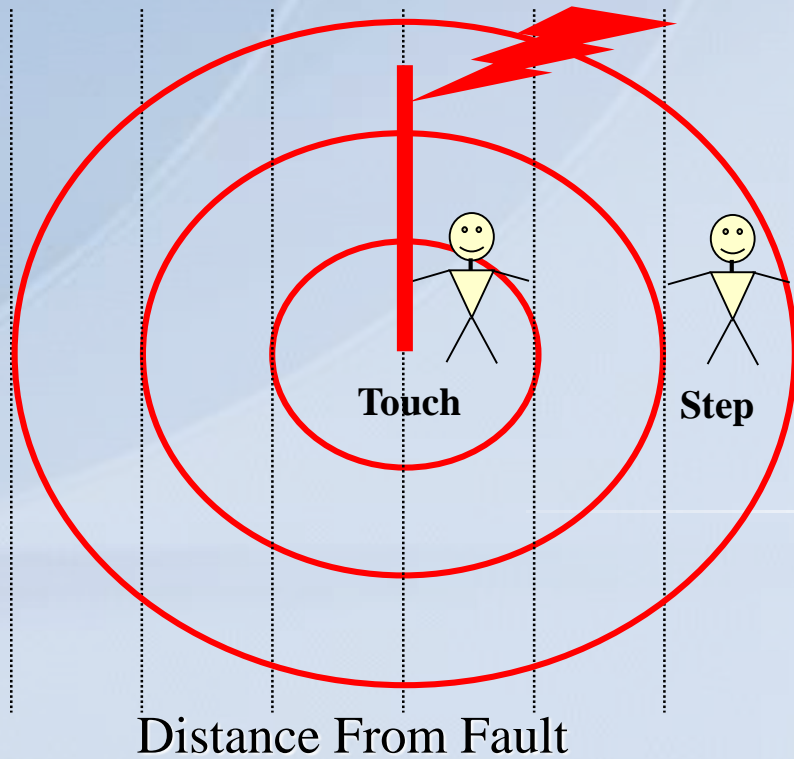
Homogeneous Soil



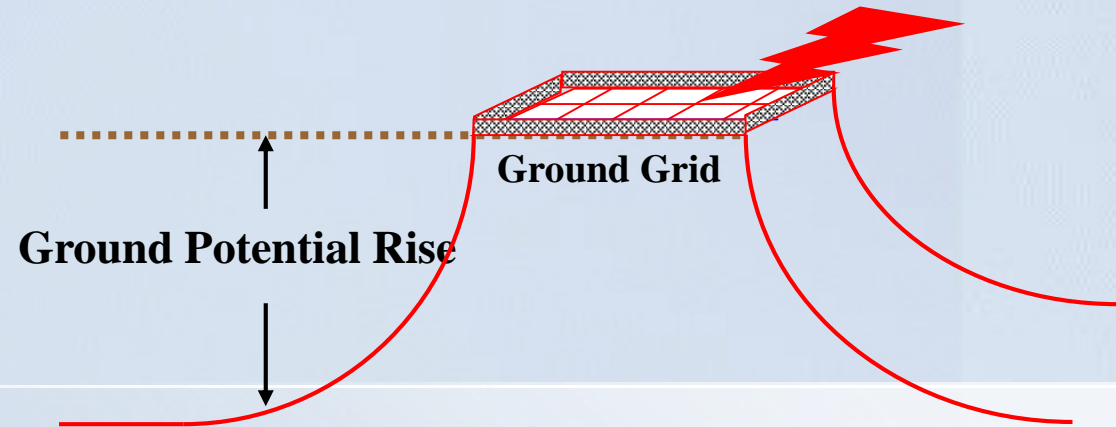
Electrical Grounding Safety

Touch & Step Potentials

Structures



Substations



Electrical Grounding Safety

Human Characteristics

NOTE: Current path through body is a critical factor!

The average 155-lb man takes the following currents:

- 1.2ma to produce a slight tingling feeling, called perception threshold
- 9ma can produce a painful shock, but still below lock-on conditions
- 16ma can cause the loss of muscle control
- 23ma can cause difficulty breathing
- 50ma approximately can cause burning
- 100ma for 3 seconds can cause heart fibrillation
- 1 amp for 30ms can cause heart fibrillation

Electrical Grounding Safety

2-Ways to be Safe!

CONDUCTION – *Equipotential Grounding*

The use of materials in situations where good conduction (low resistance) will result in small potential differences and high current flow. (Ground Jumpers)

ISOLATION – *Personal Protective Equipment*

The use of materials in situations where good insulation (high resistance) will result in large voltage differences and low current flow. (Rubber Insulation)

Electrical Grounding Safety

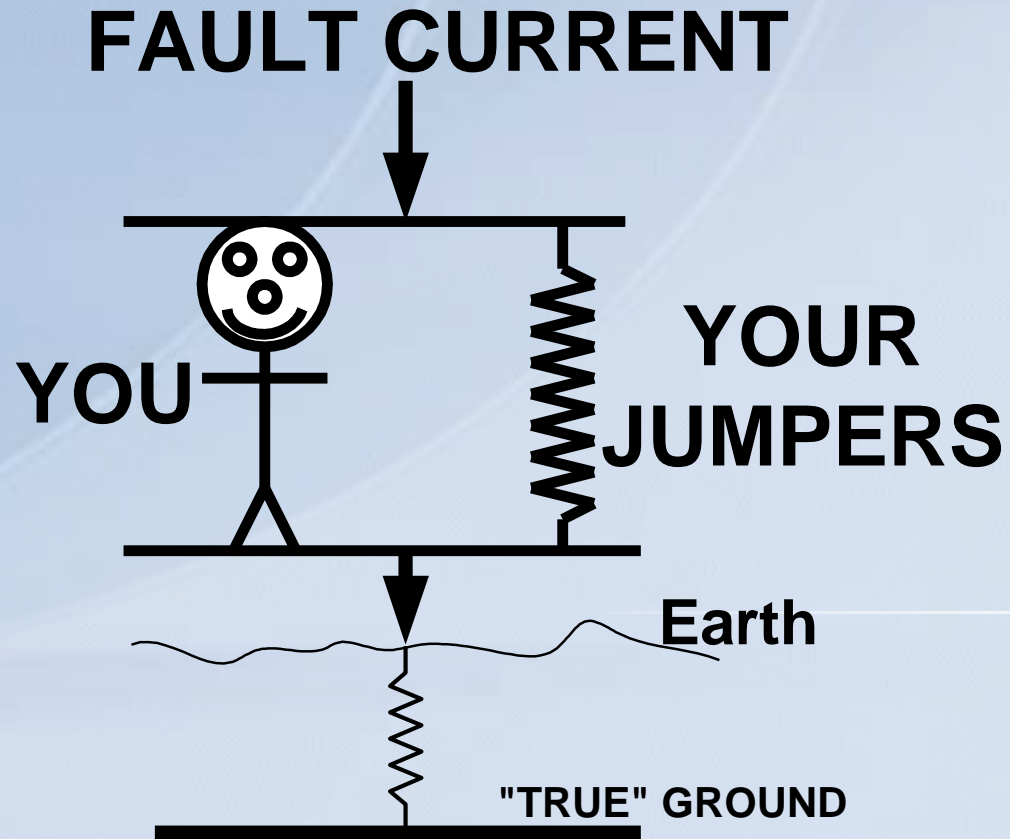
Conduction - Ground Source Preferences

1. Substation Ground Grid
2. Multi-Grounded Neutral (MGN)
3. Steel Tower or Steel Pole
4. Driven or Screw-in Ground Rods
5. Anchor Rods



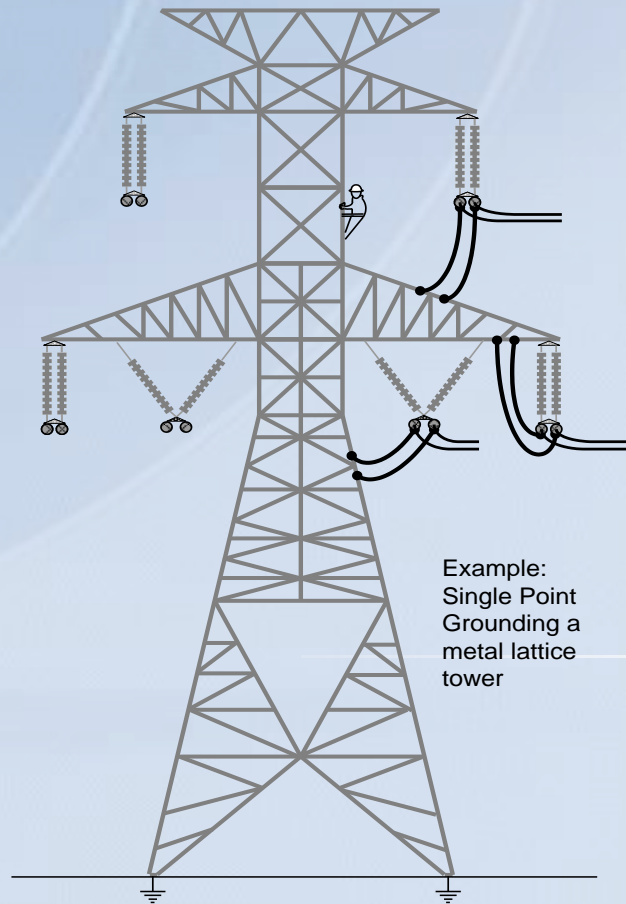
Electrical Grounding Safety

Conduction - Jumper Voltage Drop Protection



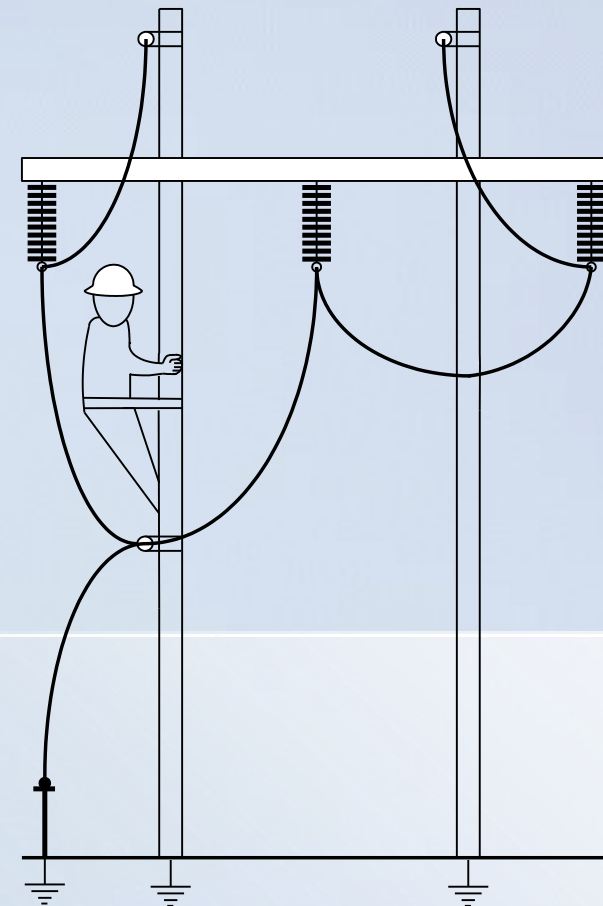
Electrical Grounding Safety

Conduction - Transmission Structure Safety



Example:
Single Point
Grounding a
metal lattice
tower

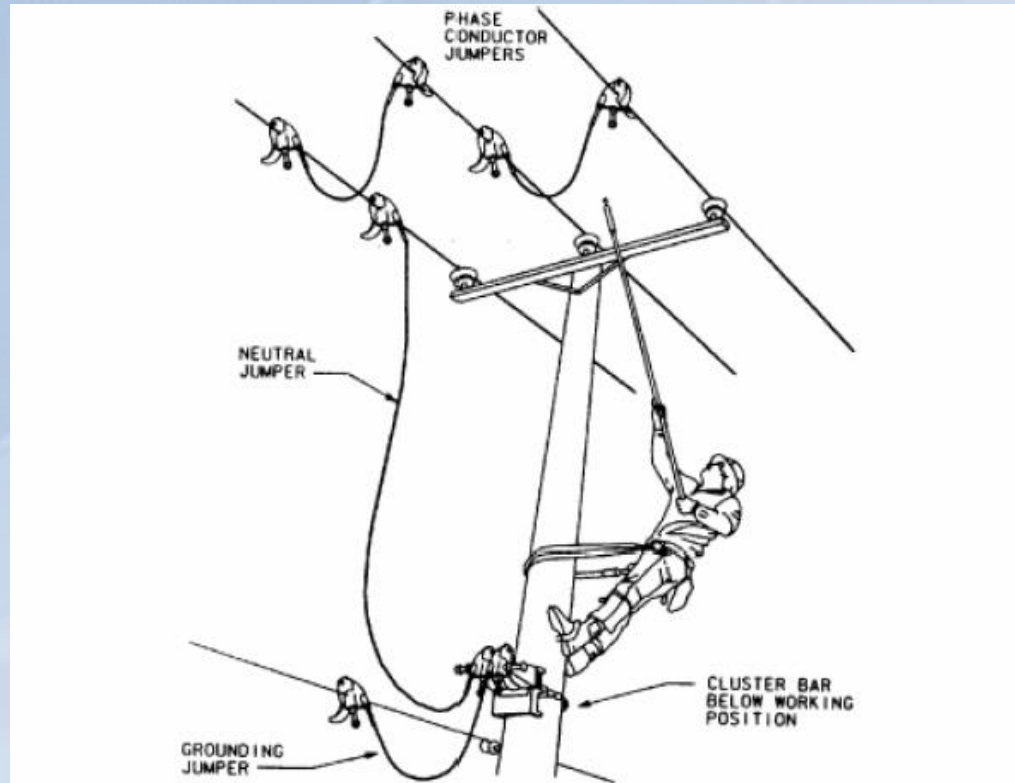
Steel Towers



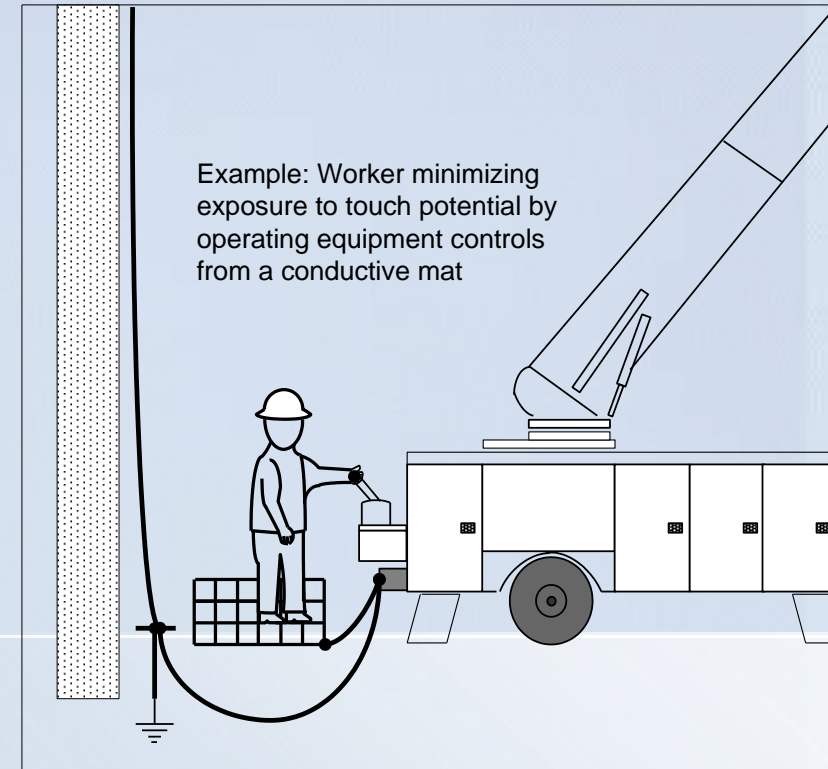
Wood Structures

Electrical Grounding Safety

Conduction - Distribution Structure Safety



Single Point Grounding



Vehicle Arrangement

Electrical Grounding Safety

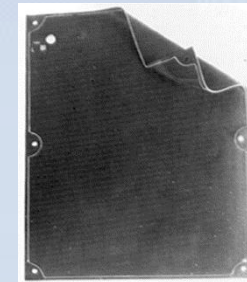
Conduction - Underground Equipment



Neutrals and Lightning Arresters are Grounded.

Electrical Grounding Safety

Isolation - Personal Protective Equipment (PPE)



Electric Power System Grounding

Any Questions?

Thank you!



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