Grounding System Design and Testing for Critical Facilities

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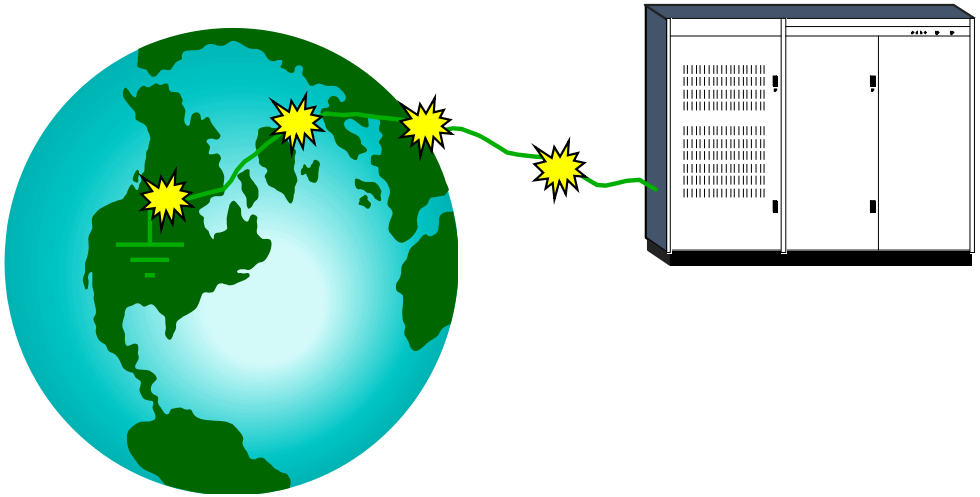
What Is Grounding?

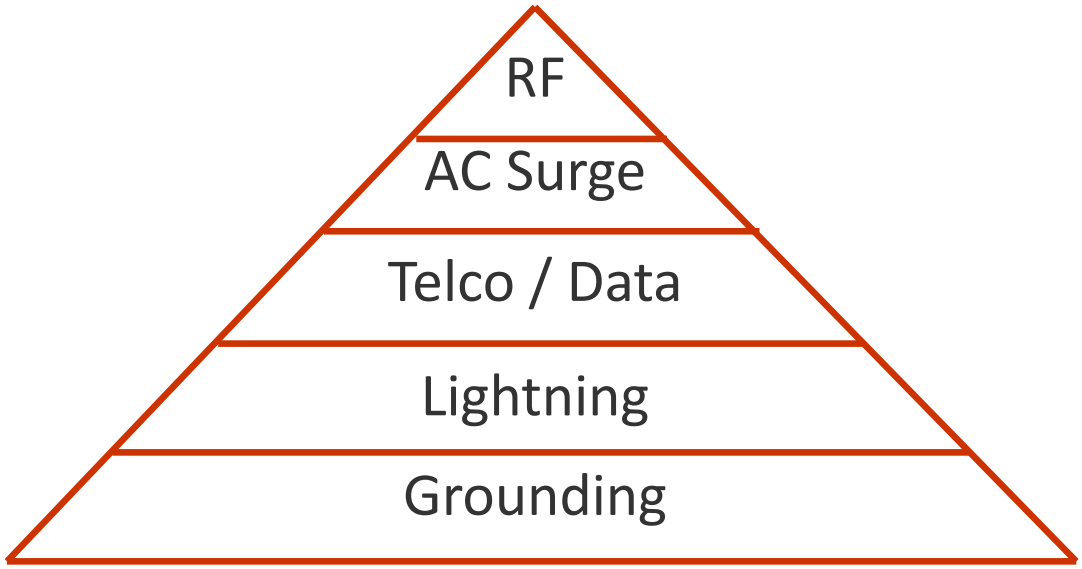


An electrical connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

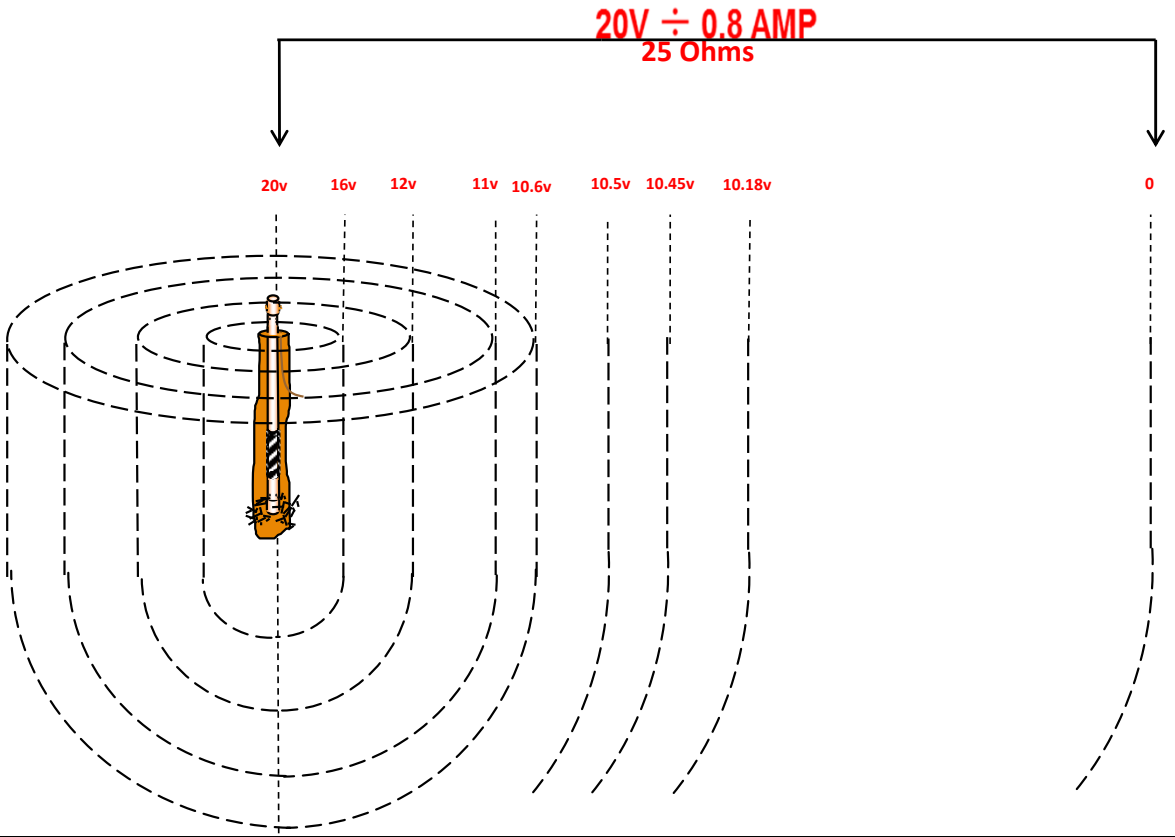
Reasons For Grounding

- Personnel safety and equipment protection by providing a path to safely dissipate any unwanted charges or potentials
- Ensure equipment performance and protection
- Satisfy manufacturer's warranty

Electrical Protection Pyramid®



Resistance To Earth



Soil Resistivity Basics

Soil Resistivity

Key Variable in System Design

- Determines grounding system resistance
- Changes from site to site
- Dependent on:
  - Soil type
  - Moisture
  - Electrolytes
  - Temperature

Soil Resistivity Comparison

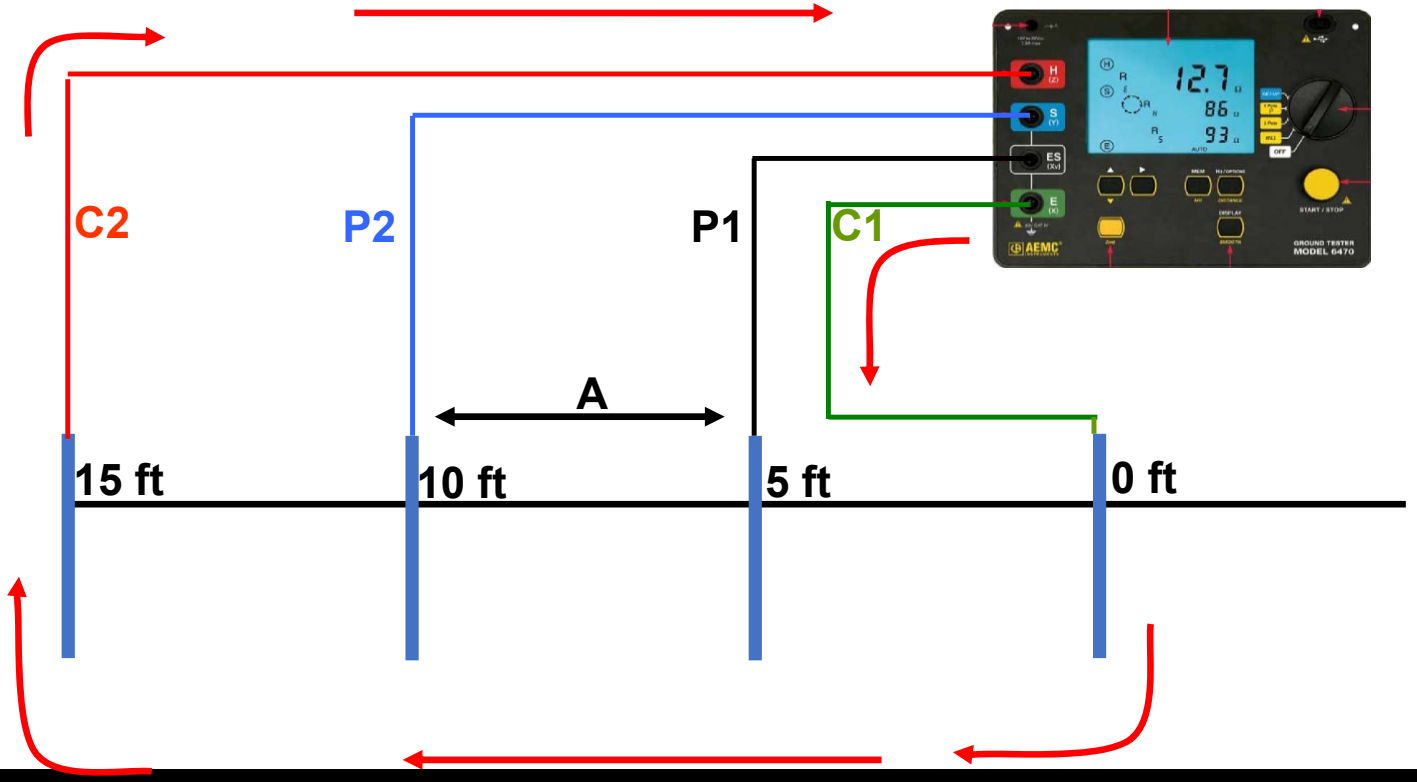
Soil Type	Resistivity (ohm-cm)		
Surface Soils	100	-	5,000
Clay	200	-	10,000
Sand and Gravel	5,000	-	100,000
Surface Limestone	10,000	-	1,000,000
Limestone	500	-	400,000
Shale	500	-	10,000
Sandstone	2,000	-	200,000
Granites, Basalts, etc.			100,000
Decomposed Gneisses	5,000	-	50,000
Slates, etc.	1,000	-	10,000

Soil Resistivity Testing

4-Pt. Wenner Method

- Visually Survey Lease Area to Determine Location and Direction For Test
  - Not parallel to buried metallic objects
  - Not parallel to overhead power lines
  - Sufficient straight line distance to allow for test
  - Minimal distance 300 feet

4-Pt. Wenner Method



4-Pt. Wenner Method

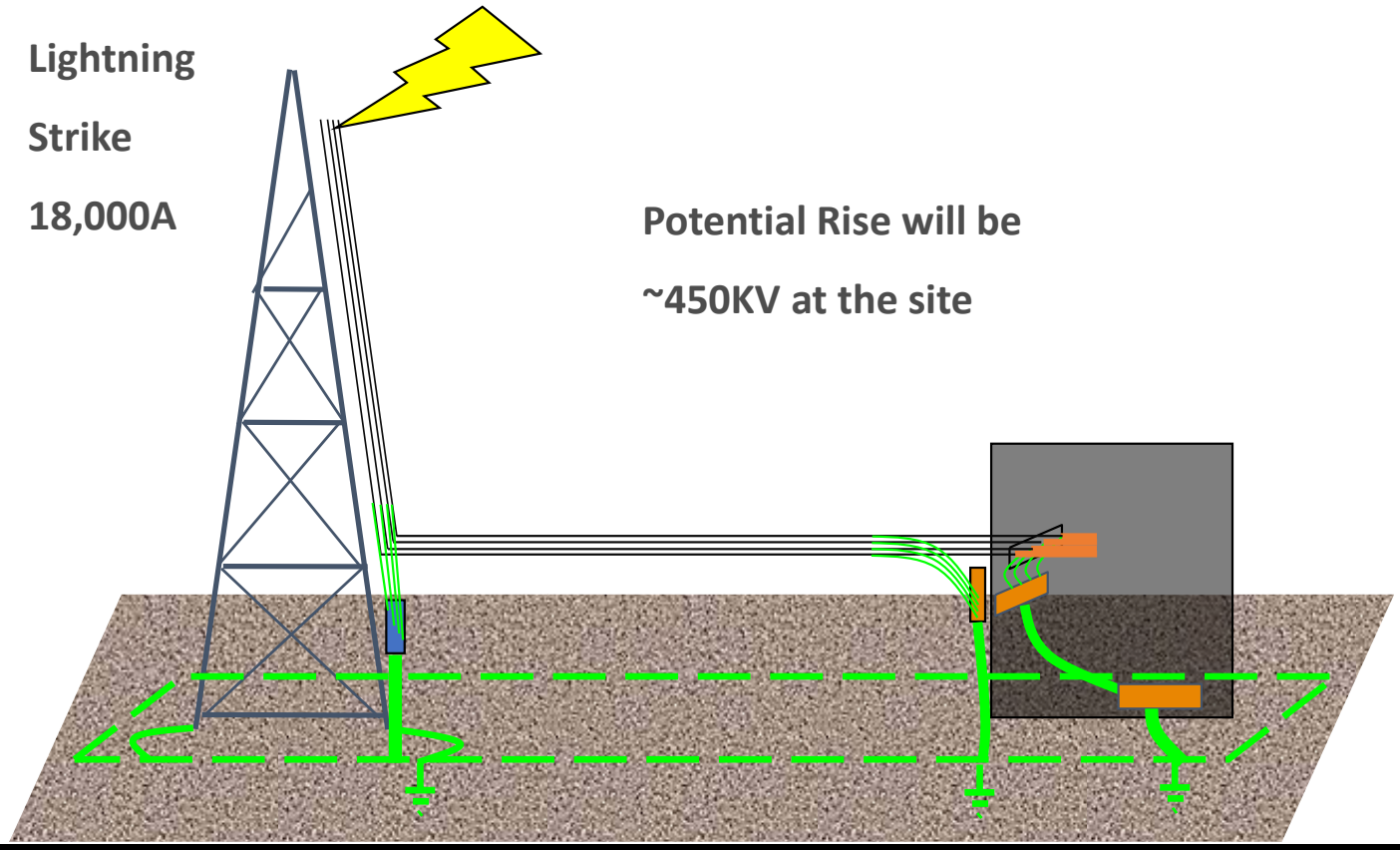
Probe Spacing (Feet)	Meter Reading (Ohms)	$\rho = 1.915\ AR$ Calculated Resistivity (Ohm-Meter)
5	52.00	497.90
10	19.68	370.87
15	10.16	292.00
20	6.53	250.10
30	4.30	247.04
40	10.80	827.28
60	7.40	850.26
80	5.58	855.60
100	4.44	850.26

Typical
Grounding Electrode System
Resistance Requirements

Typical Resistance Requirements

– NFPA 70 NEC	25 OHMS or Two Rods
– IEEE Standard 142 & 1100	Equipment Dependent
– Motorola Standard R-56	10 OHMS (Design Goal)
– Telecommunications	5 to 10 OHMS
– Emerson DeltaV	3 OHMS
– Essilor	3 OHMS
– GE Medical Systems	2 OHMS

25 Ohm Grounding System



5 Ohm Grounding System

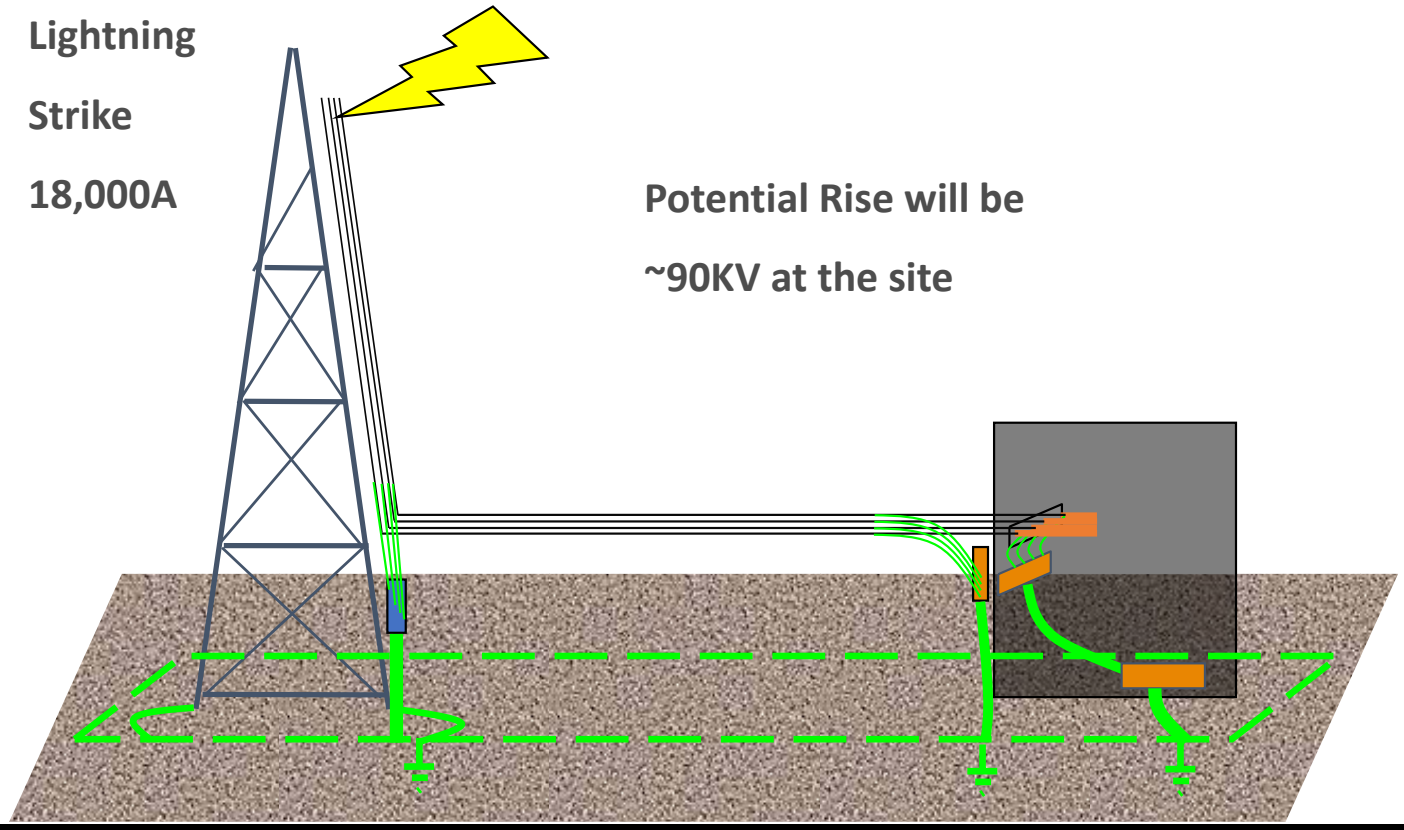
Lightning

Strike

18,000A

Potential Rise will be

~90KV at the site



Grounding System Resistance Testing

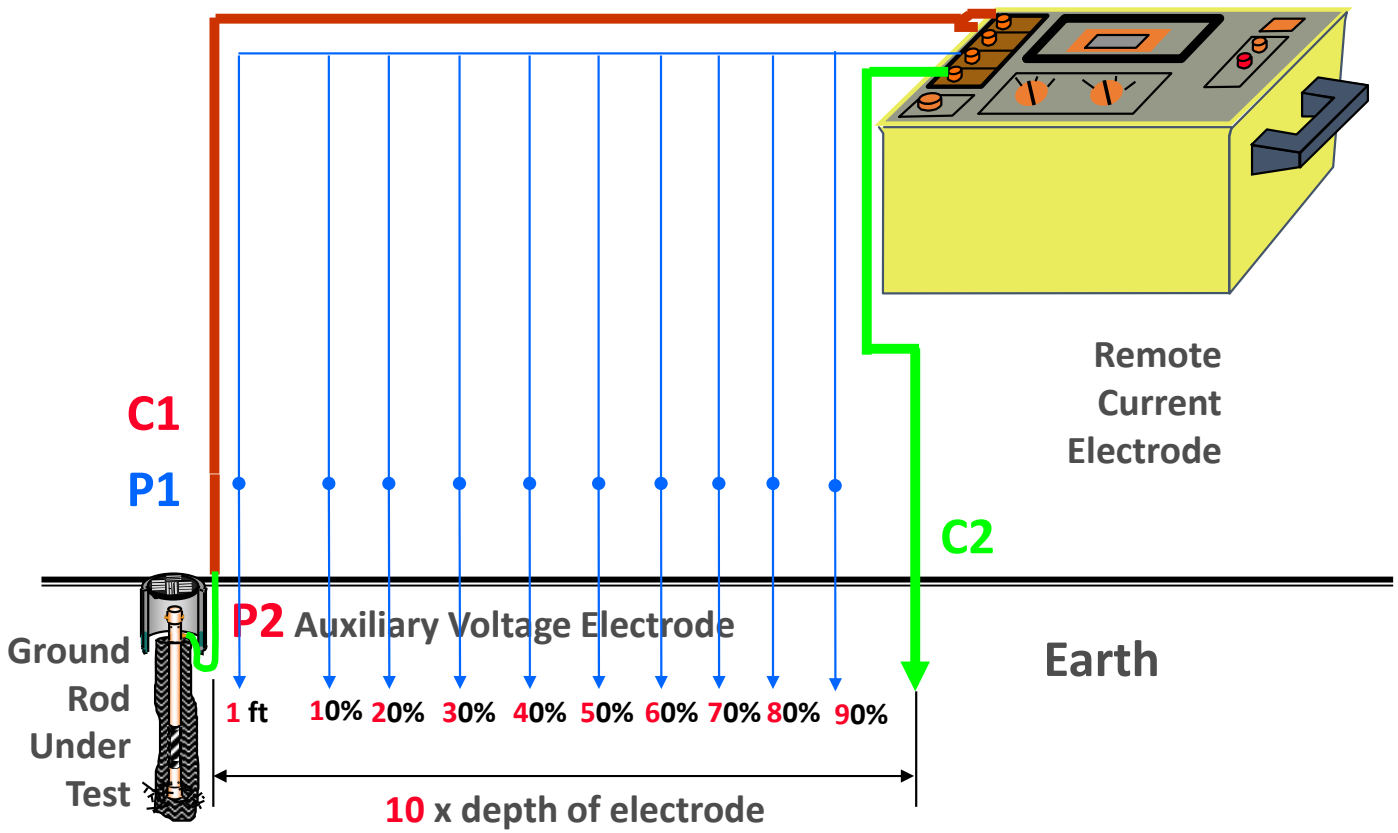
Grounding System Testing

- Why Test Grounds?
  - Determine Baseline
  - Validate Construction
  - Confirm Design Spec Satisfied
  - Satisfy Warranty Reqs
  - Ensure Equip Protection & Performance

Testing Methods

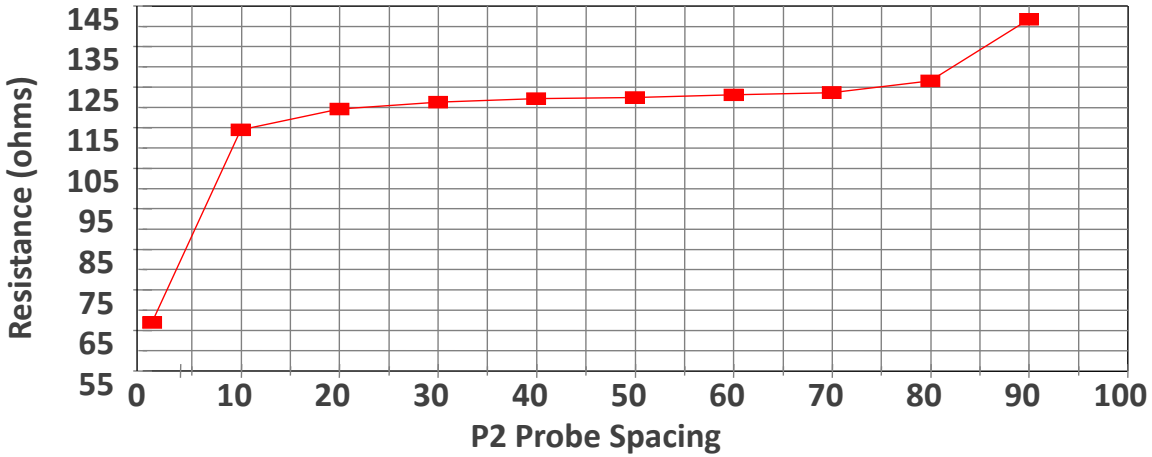
- Two Test Methods
  - Fall of Potential (Three Point) Test
  - Clamp-on Test

Fall-of-Potential Method



Fall of Potential

- Why 10+ Samples?
  - Single Point Could Be Misinterpreted
  - Data Must Be Plotted
    - Visual Plateau
    - Confirms Test Validity



Fall of Potential Test

Why Invalid?

- #1 Reason
  - Not Isolating System Under Test
    - Meter is a constant amperage meter
    - Part of the current travels through the connection
    - The ground system is part of a parallel network
  - Test Is <u>Invalid</u> Unless Disconnected

Fall of Potential Test

Why Invalid?

- #2 Reason
  - Insufficient Probe Spacing
    - Req'd to Avoid the Spheres of Influence

Fall of Potential Test

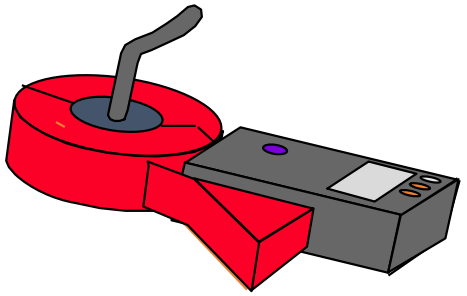
- Spacing For Current Probe?
  - Single Electrode
    - Minimum 5X Length of Rod
    - Ideal, 10X Length of Rod
      - 10 Foot Rod, 50-100 Feet Away
      - 200 Foot Well, 1000-2000 Feet Away

Clamp-on Ground Resistance Testing

Clamp-on Resistance Testing

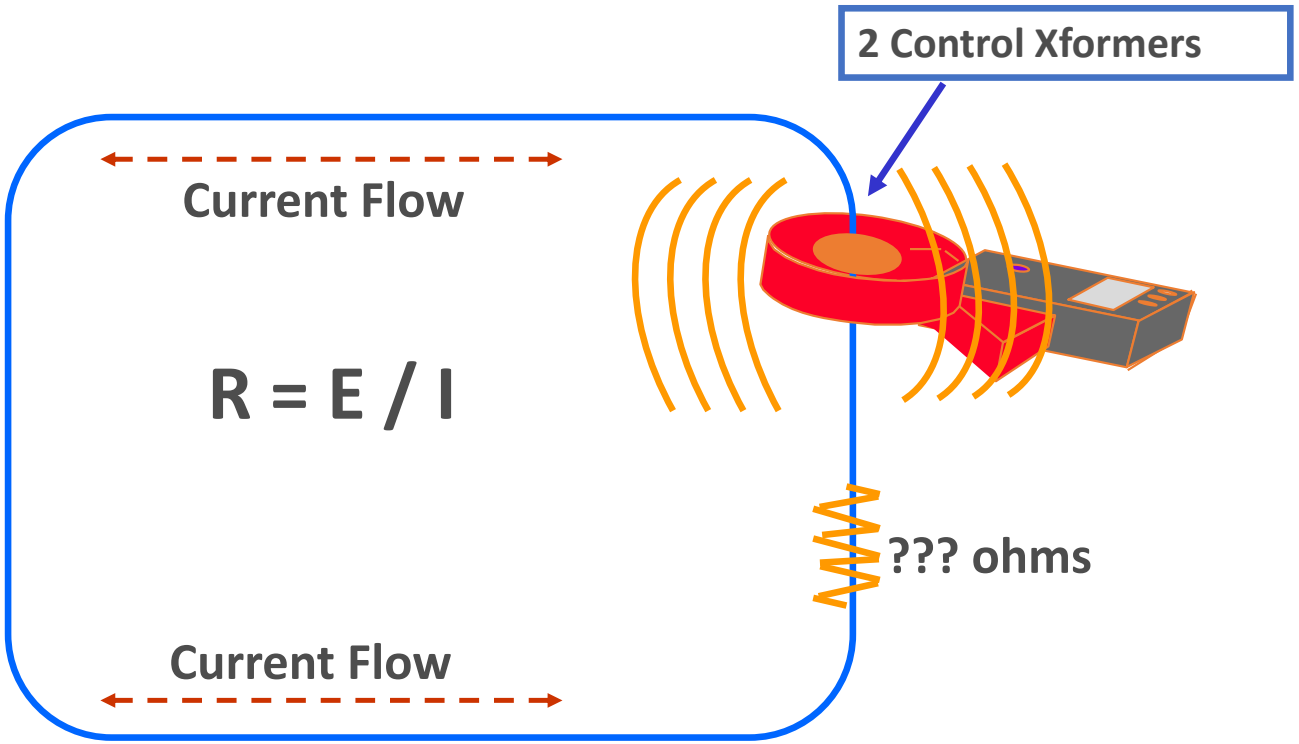
Clamp-on Ground Resistance Meter

- Convenient, Quick, Easy
- Does Not Require Disconnecting Equipment
- Measures Current on the Ground

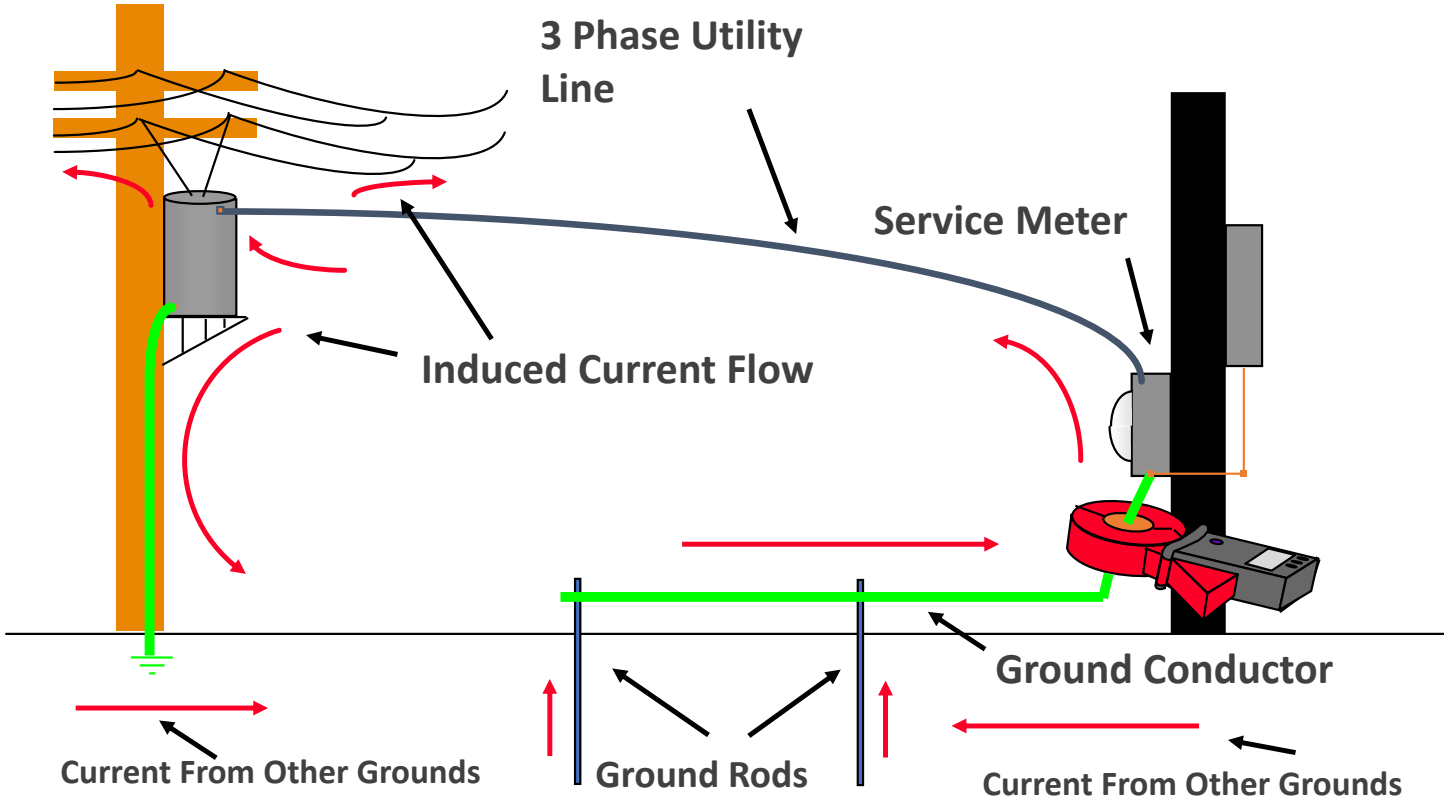


May Read Ground Loops vs. Ground Resistance

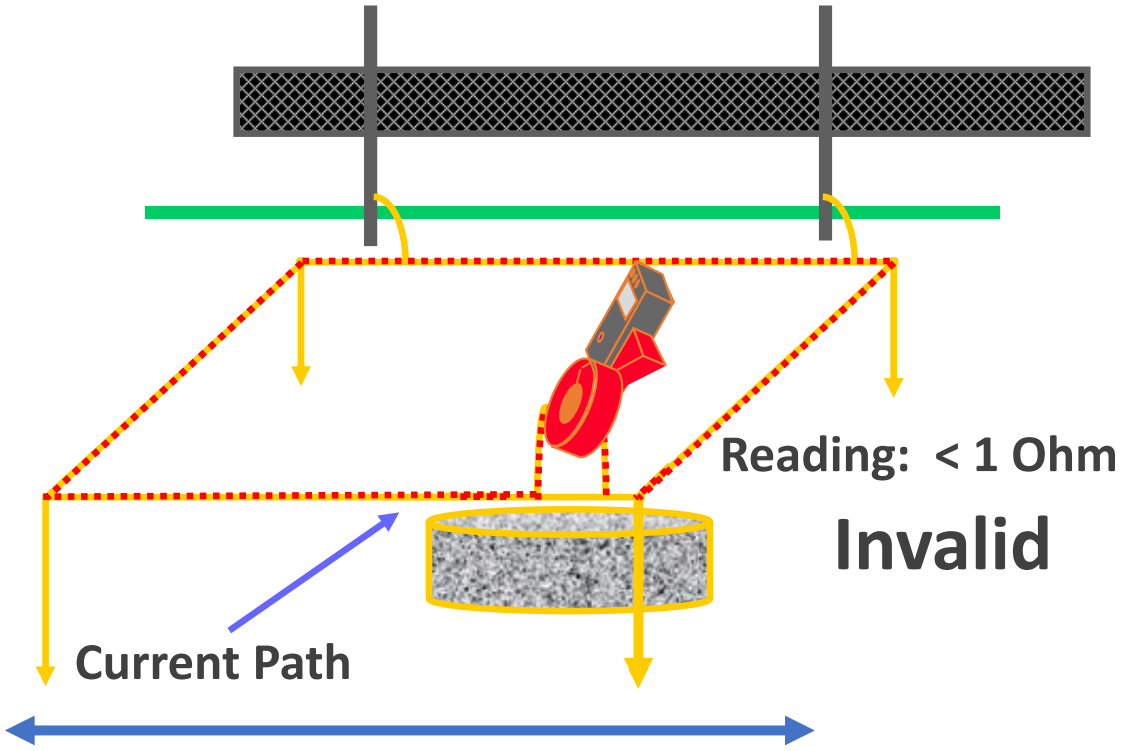
Clamp-on Meter Operation



Clamp-on Resistance Testing Example



Invalid Clamp-on Reading



Bonding

Bonding

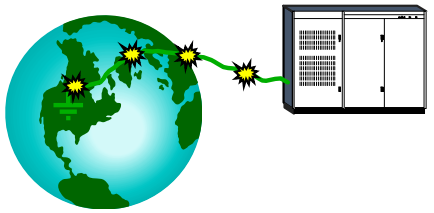
Do the words bonding and grounding mean the same thing?

- ***Bonding*** - **The permanent joining of two metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to safely conduct any current likely to be imposed.**







- ***Grounding*** - **An electrical connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.**

Bonding

Why is Bonding More Important Now than Ever Before?

Grounding Processes/Grounding Electrode Systems -V- Technological Advances

- **Except for the advent of electrolytic electrodes and different grounding enhancement materials, grounding processes and grounding electrode systems have changed little in the past 100 years.**
- **Are we using the same technology that our grandparents did?**
  - **Personal Computers**
  - **Television**
  - **Microwave**
  - **Radar**
  - **Solar Panels**
  - **Electronic Points of Sale Systems**
  - **Electronic Cash Registers**
  - **Voice Over Internet Protocol**
  - **Cellular Telephone**
  - **Ground Positioning Systems**
  - **Photovoltaic Cells**
  - **Radio Communications**
  - **Computer Controlled Manufacturing**
  - **Medical Equipment**
  - **Fiber Optic Voice/Data Transfer**
  - **Digital Networking**

THANK YOU FOR YOUR ATTENTION

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