

ECE 528 – Understanding Power Quality

<http://www.ece.uidaho.edu/ee/power/ECE528/>

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Lecture 37

1

Today...

- Wiring and grounding
 - Why it's important
 - References
 - Terms and definitions
 - Start on some common problems

Goals of this portion of the course:

Become familiar with some important power quality-related wiring and grounding issues, and the resources available to engineers for more information on wiring and grounding.

Lecture 37

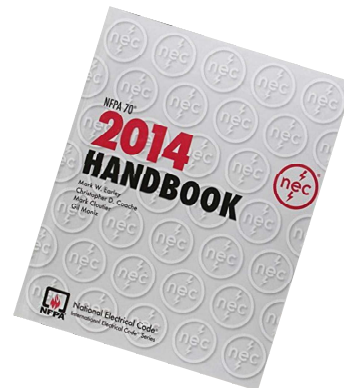
2

Introduction

- Wiring and grounding problems...
 - May result in property damage, injury, or death
 - Are frequent contributors to power quality problems
 - Can significantly impact the operation of sensitive equipment
 - Are preventable

Standards and references

- US Standards:
 - National Electric Code (NEC)
 - Requirements are designed specifically to protect persons and property from hazards associated with the use of electricity
 - Requirements are NOT designed to prevent power quality problems
 - Not a design specification or “how-to” manual
- Note: The National Electric Code *Handbook* adds a considerable amount of explanatory material and is recommended over the code book itself



Standards and references

IEEE Standards:

- IEEE Std. 142 (2007)– (The Green Book) – *Recommended Practice for Grounding of Industrial and Commercial Power Systems*
- IEEE Std. 1100 (2005)– (The Emerald Book) – *Recommended Practice for Powering and Grounding Sensitive Electronic Equipment*

• References:

- *Soares Book on Grounding and Bonding*, (latest edition)– published by the International Association of Electrical Inspectors
- *Electrical Wiring, Residential*, by R.C. Mullen and Phil Simmons
- *Electrical Wiring, Commercial*, by R.C. Mullen and Phil Simmons
- *Electrical Wiring, Industrial*, by S.L. Herman

Terminology

• NEC use of “grounded” and “grounding”

- “Grounded conductor”
 - An intentionally grounded circuit conductor – oftent the neutral conductor
 - Remember – Not Dead
- “Grounding conductor”
 - Connects equipment (cases) or the grounded conductor to grounding electrodes (ground rods, etc.) – the ground wires
 - Remember – In or near ground

Grounding versus bonding

- Grounding
 - Connecting equipment and points on electrical systems to the earth or an earth substitute
 - Purpose is to limit overvoltages between the equipment and the earth due to lightning, faults, etc.
- Bonding
 - Connecting equipment together to establish electrical continuity and conductivity
 - Purpose is to limit voltages between equipment and to provide a path for ground fault current

Reasons for grounding and bonding

- Safety grounding and bonding
 - Minimum requirements are described in NEC- 2014, primarily in article 250
 - Personnel safety
 - Prevent voltage differences between electrical enclosures and devices, and surrounding conductive surfaces
 - Ensure protective device operation
 - Provide low-impedance path for the flow of “ground fault” current so that enough fault current flows to quickly blow a fuse or trip a circuit breaker

Reasons for grounding and bonding

- Power Quality or "Performance" grounding and bonding - Noise control
 - Purpose is to create an equipotential ground system – may be a "signal reference grid" or "signal reference plane"
 - A grid or plane can provide a relatively uniform impedance across a very wide range of frequencies
 - Minimizes voltage differences between the "grounds" of interconnected sensitive electronic devices – typically computers or communications systems

Reasons for grounding and bonding

- Power Quality or "Performance" grounding and bonding - Noise control
 - Typically requires more specialized grounding than what is described in NEC article 250
 - NEC-2014, Article 645 briefly covers computer room grounding and bonding
 - NEC-2014, Article 725 covers remote-control and signaling systems
 - NEC-2014, Article 800 covers communication systems

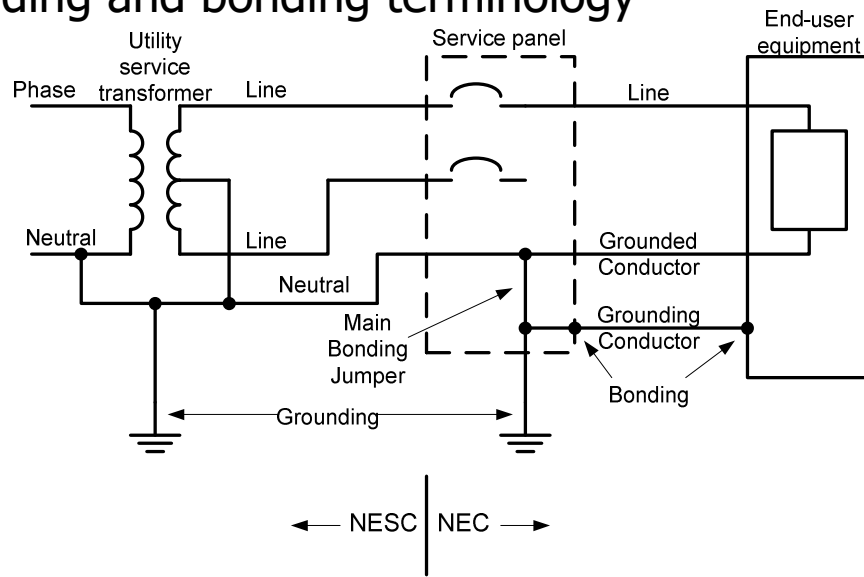
Grounding and bonding frequency considerations

- Safety grounding and bonding
 - Frequencies of interest tend to be low; dc to several hundred or a few thousand Hz
 - Wavelength is not a consideration
- Power Quality or performance grounding and bonding
 - Frequencies of interest are dc to tens of MHz or higher
 - Wavelength becomes a consideration

Grounding and bonding problems

- The grounding and bonding requirements designed to ensure safety always apply and take precedence over any other grounding and bonding objectives
- Many safety issues associated with grounding and bonding are the result of misguided efforts to improve power quality
- These efforts often hurt power quality as well

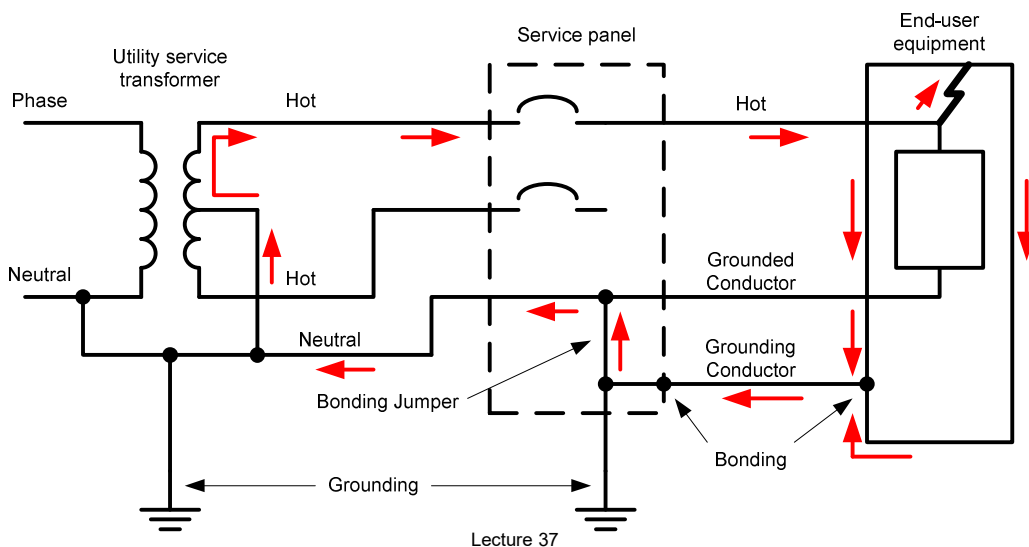
Grounding and bonding terminology



Lecture 37

13

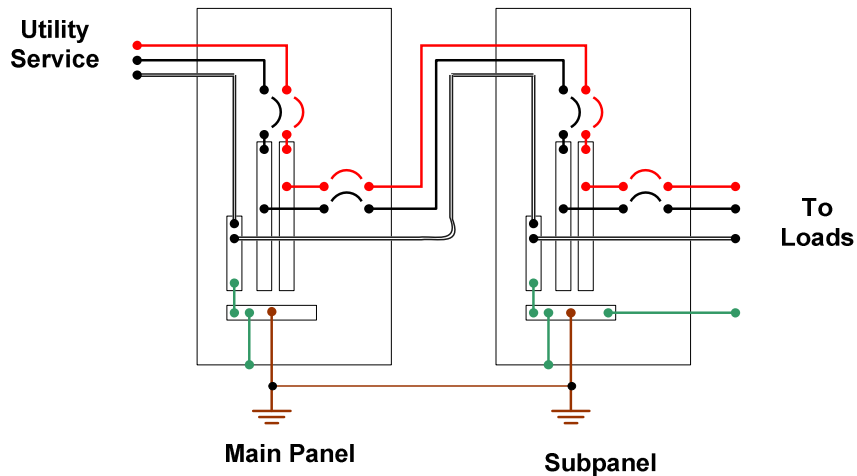
Safety - A faulted system



Lecture 37

14

Wiring and grounding problems: Multiple neutral-to-ground bonds



Lecture 37

15

Wiring and grounding problems: Multiple neutral-to-ground bonds

- Issues:
 - Results in load current on the grounding system
 - May interfere with protective devices
 - Creates “ground loops”
 - Results in “net current” and elevated magnetic fields around cables and conduits

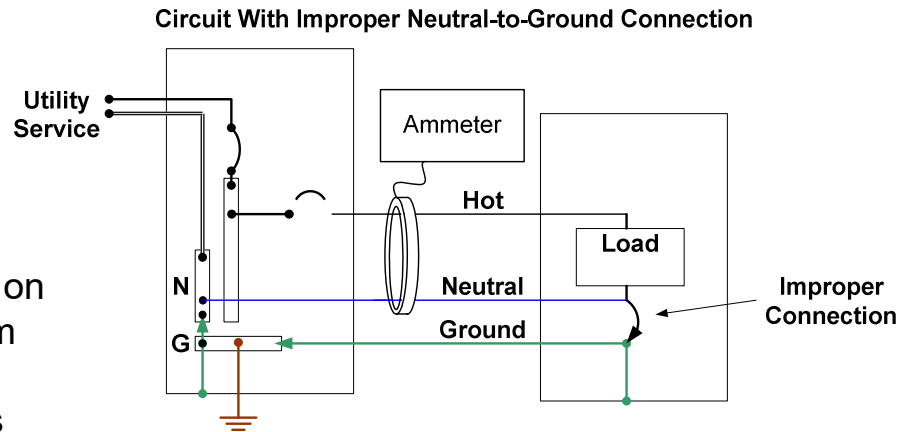
Lecture 37

16

Locating extra neutral-to-ground bonds:

Methods

- Visual inspection
- Measure current on grounding system
- Measure net current in circuits



This test is minimally invasive, and can be done without dismantling the circuits.

Lecture 37

17

Wiring and grounding problems: Missing equipment grounding

- (PSQ page 474, fig. 10-2)
 - Issues
 - Return path impedance for ground-fault current is high, (sometimes very high)
 - Equipment case may become energized
 - Ground-fault current may not trip a circuit breaker
 - How would you locate this problem?

Lecture 37

18

Locating missing grounding

- Visual inspection
- Measure voltage between points that should be bonded together
 - Measure neutral-to-ground voltage at receptacles
 - Should be low (<3V)
 - Zero may indicate an extra N-G bond
 - Measure line-to-ground voltages in panels
 - Should be close to nominal L-G voltage for the system

Coming up...

- More wiring and grounding
 - Voltage gradients
 - Neutral sizing
 - Separately derived systems
 - Isolated grounds
 - Wiring for communications