

ECE 528 – Understanding Power Quality

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

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Today...

- More wiring and grounding
 - Troubleshooting loose connections
 - Symptoms
 - Locating loose connections
 - A loose connection case study

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Causes of loose, arcing connections

- Vibration
- Temperature fluctuations
- Other work in the area
- Poor installation
 - Wrong size wire in connector
 - Wire around screw in wrong direction
 - Too little wire in connector
- Corrosion and contamination

Symptoms of loose connections

- Loose connections may cause many of the common power quality problems we have discussed
 - Voltage sags and undervoltage
 - Additional voltage drop across a loose connection results in lower voltage at the downstream load
 - Voltage swells and overvoltage
 - Additional voltage drop across a shared neutral will result in a voltage swell on other phases
 - Transients
 - Connections may arc, resulting in high frequency transients

Symptoms of loose connections continued...

- Disturbances may appear to be random
 - No correlation to known utility system disturbances
 - Connection may not be loose all the time
 - arcing can cause melting and “welding” of the connection
 - Voltage drop across high-resistance connections depends on load current
 - May not be noticeable during periods of light loading
 - Some loads may not be impacted by the loose connection
 - Impact of poor neutral connections depends on load balance

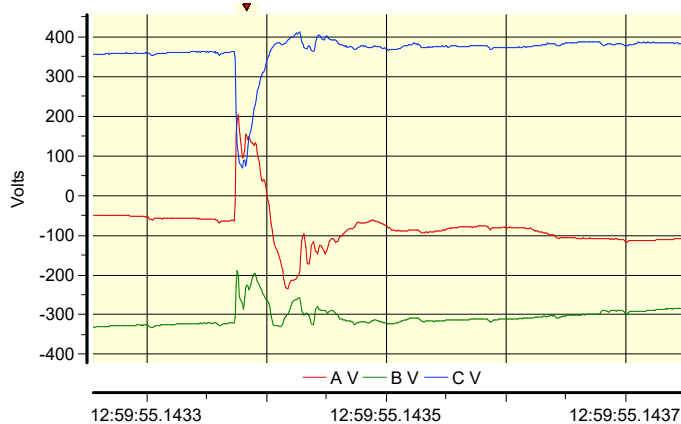
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Identifying arcing in waveforms

Notice the time-scale...

Event Details/Waveforms

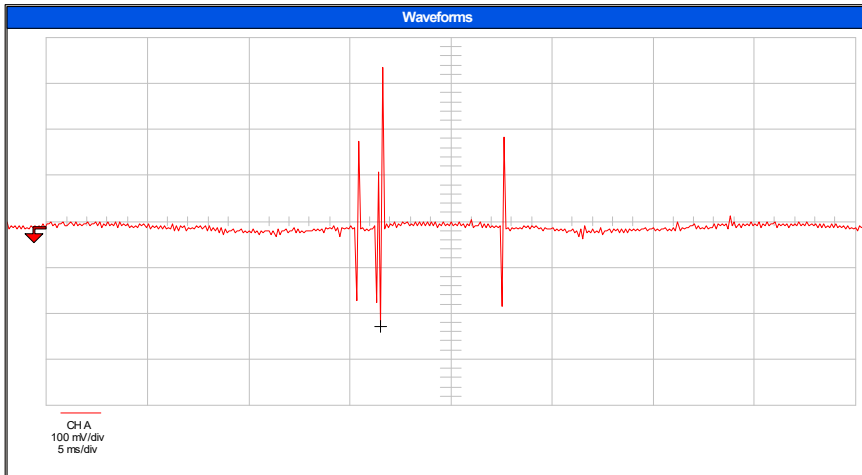


- Nearly instantaneous voltage or current changes indicate arcing
- Power system wiring tends to act like a low-pass filter. The presence of very high frequency components means the arcing is close to the power quality recorder.

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Indication of arcing in a recorded waveform



Recorded with a high frequency current clamp on a grounding conductor

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Finding poor connections after symptoms are reported or recorded

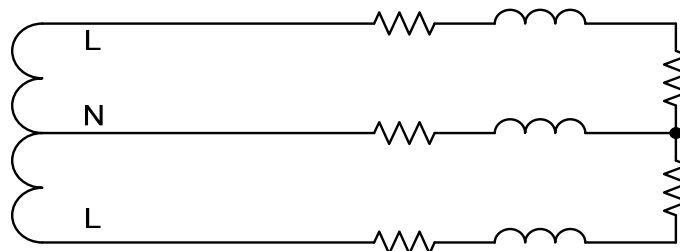
- Two main methods

- Look for heat or its effects

$$I^2 \times R = \text{Watts} = \text{Heat}$$

- Look for excessive voltage drop

$$I \times R = V = \text{Voltage Drop}$$



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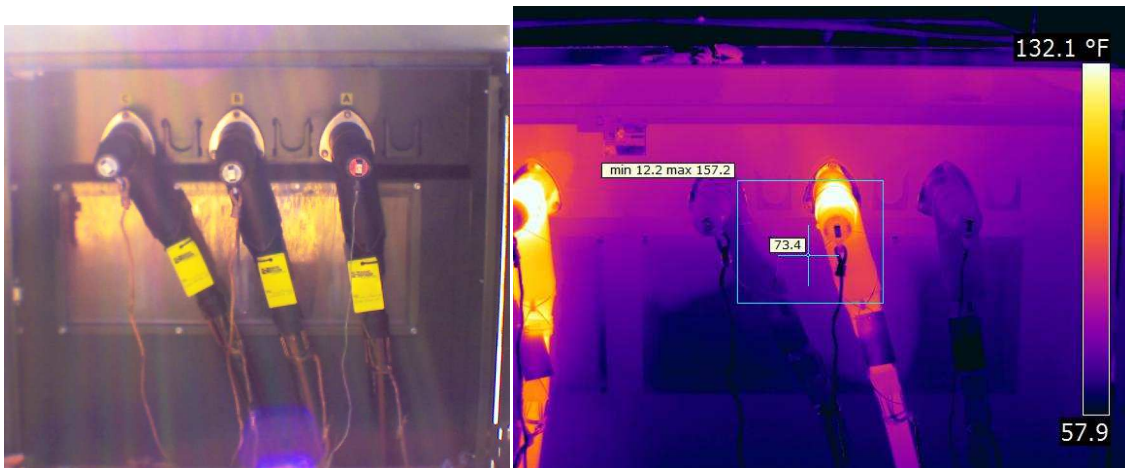
Loose connections and heating

- “Sensory” inspection – what do you see, hear, and smell?
 - You may see:
 - Melted insulation near a poor connection
 - Arcing at the poor connection
 - Light or dark gray smoke-like stains – may result from arcing and vaporizing of aluminum and copper
 - Heat – infrared thermometer or infrared camera is very helpful
 - You may hear:
 - Crackling or buzzing sound associated with arcing
 - You may smell:
 - Burnt electrical ozone smell

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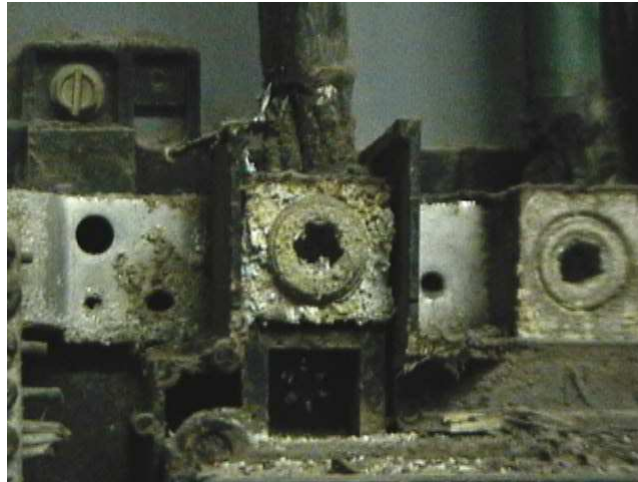
Seeing loose connections with an infrared camera



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A contaminated, corroded connection



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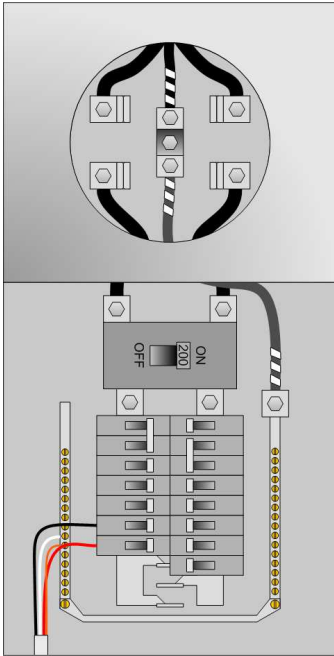
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A corroded, broken grounding connection



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Using voltage drop to check connections

How many connections are between an incoming conductor and a conductor leaving the panel?

Line:

Neutral:

We will use **voltage drop** to check connections:

Tools:

Resistive load $\approx 1.5\text{kW}$ (hair dryer or similar)

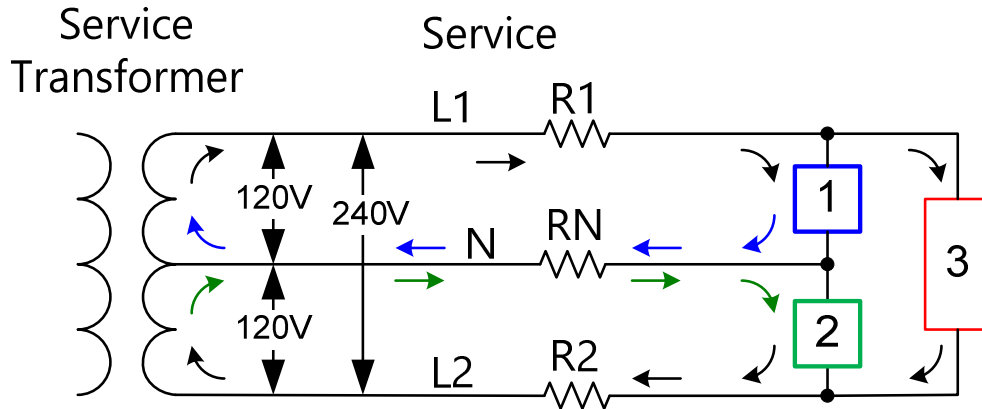
Multimeter with voltage probes

Receptacle with alligator clips

Case study: A loose connection

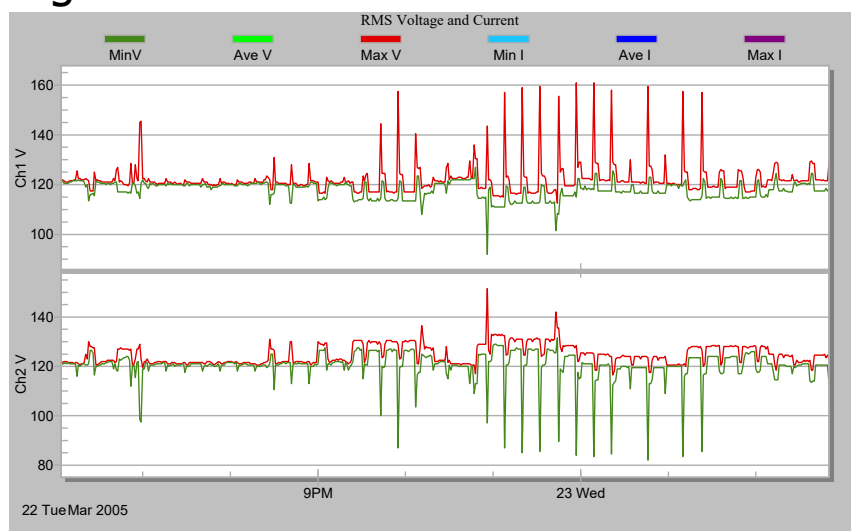
- Customer's reported symptoms
 - Lights in the garage get dim suddenly
 - Light bulbs in other parts of the house seem to get bright all of a sudden, and are failing after only a short time
 - Disturbances seem random
 - Customer didn't know if neighbors were experiencing similar problems or not

Simplified diagram of the electric service



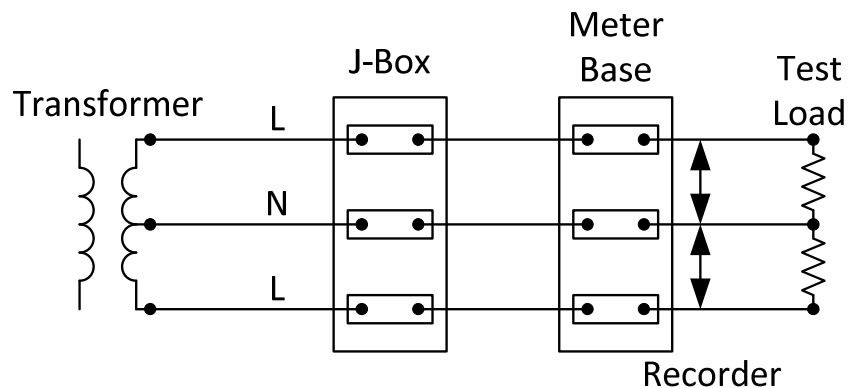
Note which loads are impacted if the voltage drop across R1, RN, or R2 is excessive.
 Excessive voltage drop across R1: Loads 1 and 3 impacted
 Excessive voltage drop across R2: Loads 2 and 3 impacted
 Excessive voltage drop across RN: Loads 1 and 2 impacted, with opposite effects

Recording at customer's meter socket



Actual connections between transformer and meter base

- Which connections do we need to check?



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Case study conclusion:

- Voltage measurements across connections in meter base were normal (approximately the same as shorted leads).
- Voltage measurement across one neutral connection in the junction box was much higher than normal ($> 10V$ during test.)
- Conclusion - neutral connection in the junction box was loose or damaged.

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Coming up:

- 41: Communications wiring
 - UTP - Unshielded Twisted Pair
 - 42: PQ recorders / Stray voltage
 - Recorder location and impact on what we record
 - 43: PQ equipment and tools / Wiring and grounding summary
 - 44: Summary / closing remarks
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- Your turn to grade me:
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