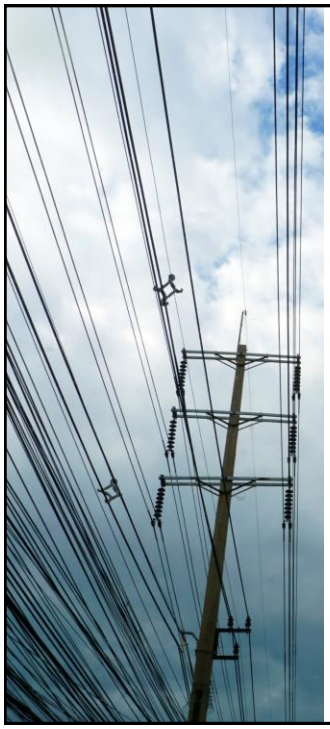
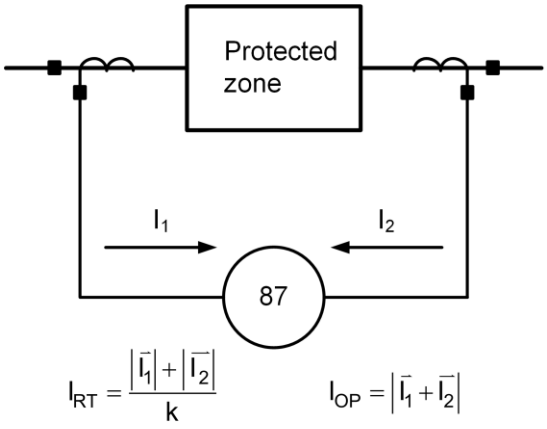


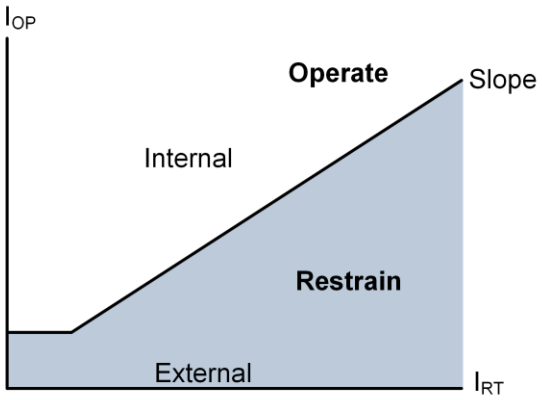
Finding Common Ground: A Case Study of Phantom Currents and Ground Loops

Matthew Boecker and Genardo Corpuz,
Lower Colorado River Authority

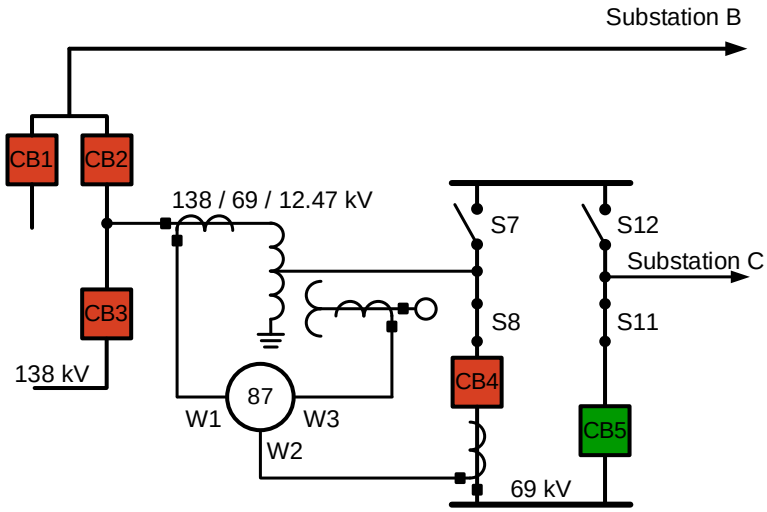
Jared Candelaria and Ariana Hargrave,
Schweitzer Engineering Laboratories, Inc.

Transformer differential protection review

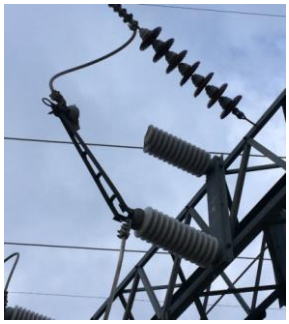


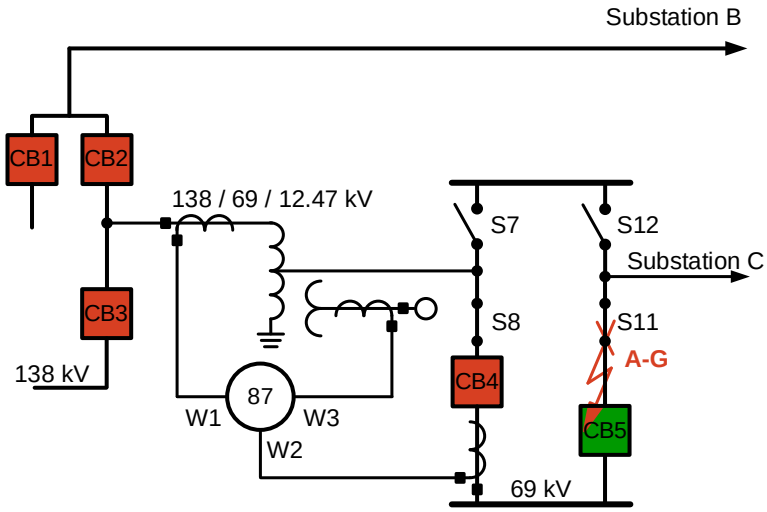


System configuration



Fault 1





Date – February 14, 2018

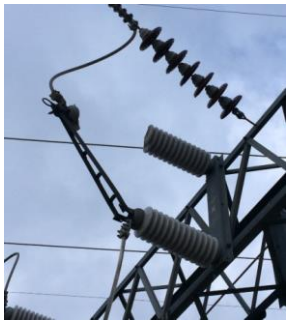
Time – 3:34 a.m.

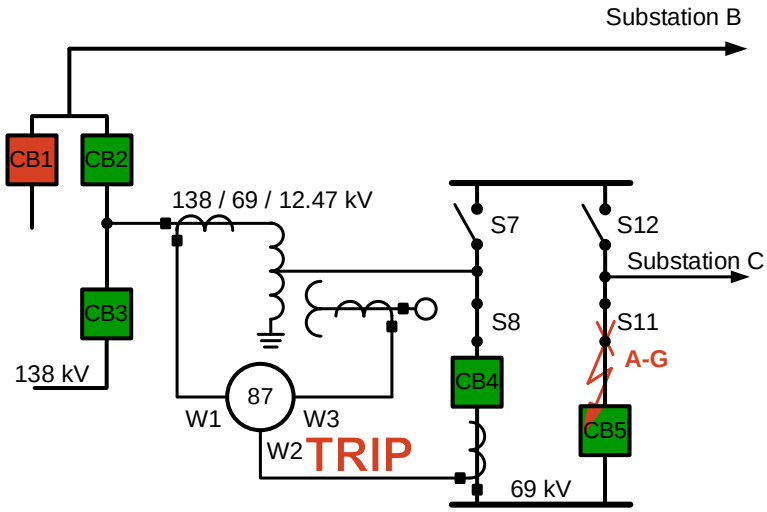
Fault type – A-G on Switch 11

Cause – Flashover

Result – 87 relay trips on 87R (C-phase)

Fault 1





Date – February 14, 2018

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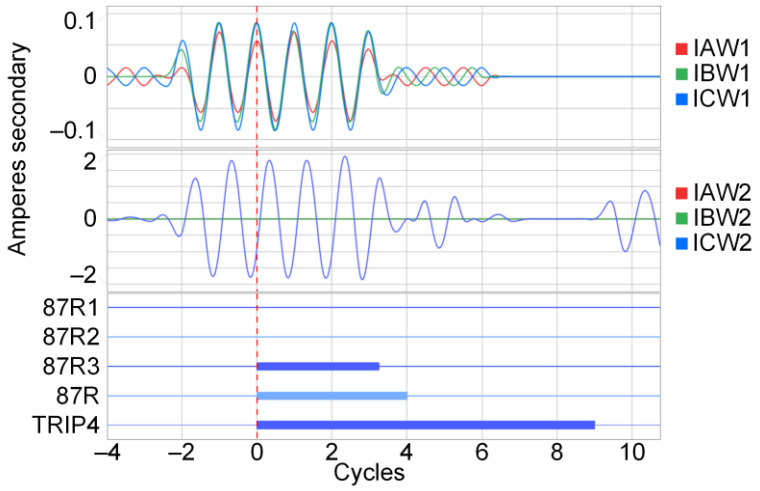
Fault type – A-G on Switch 11

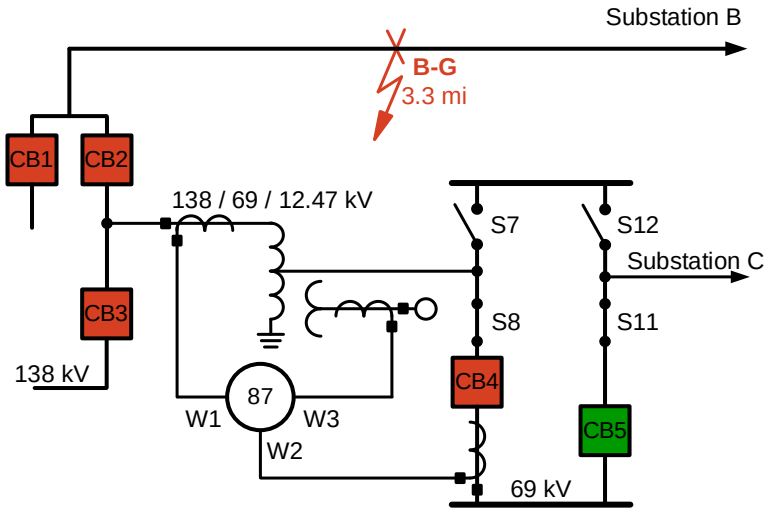
Cause – Flashover

Result – 87 relay trips on 87R (C-phase)

Fault 1 event report



Fault 2



Date – February 20, 2018

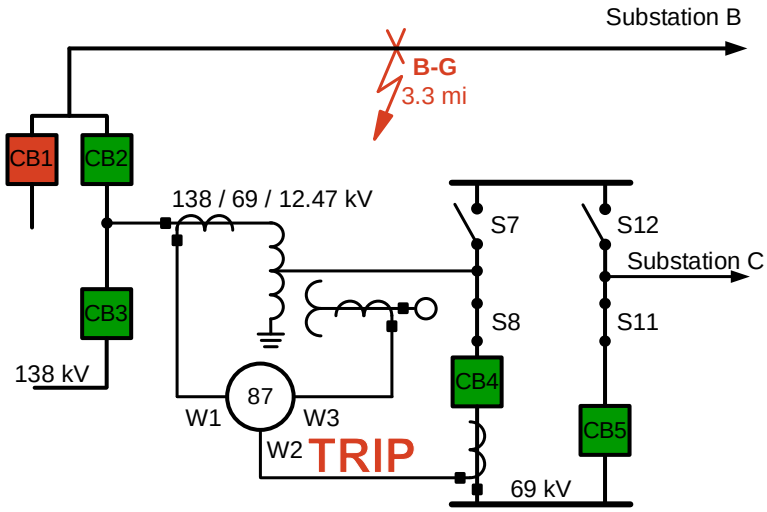
Time – 11:55 p.m.

Fault type – B-G

Cause – Lightning

Result – 87 relay trips on 87R (C-phase)

Fault 2



Date – February 20, 2018

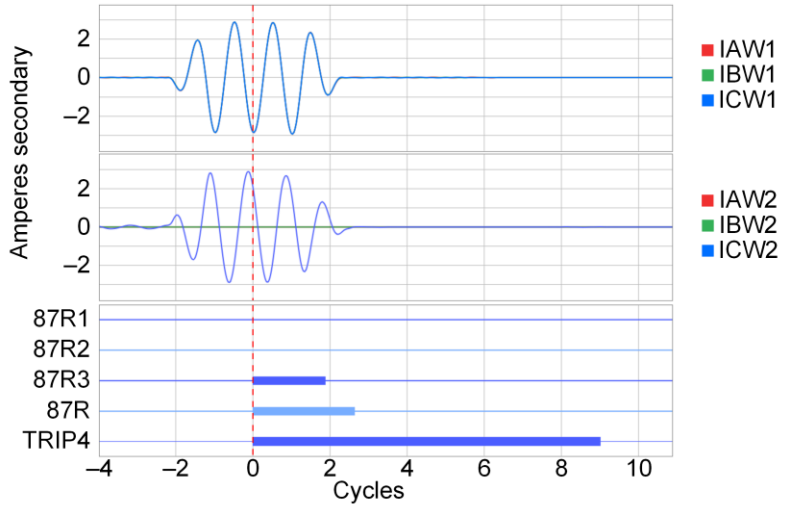
Time – 11:55 p.m.

Fault type – B-G

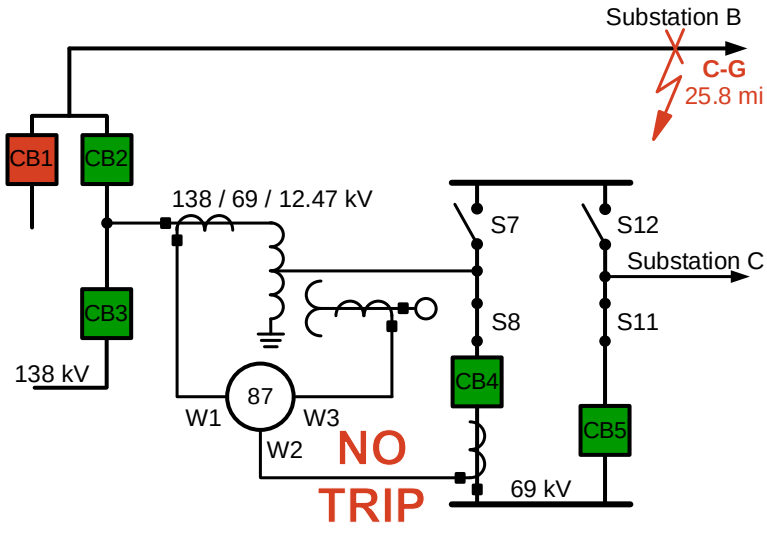
Cause – Lightning

Result – 87 relay trips on 87R (C-phase)

Fault 2 event report



Fault 3



Date – February 21, 2018

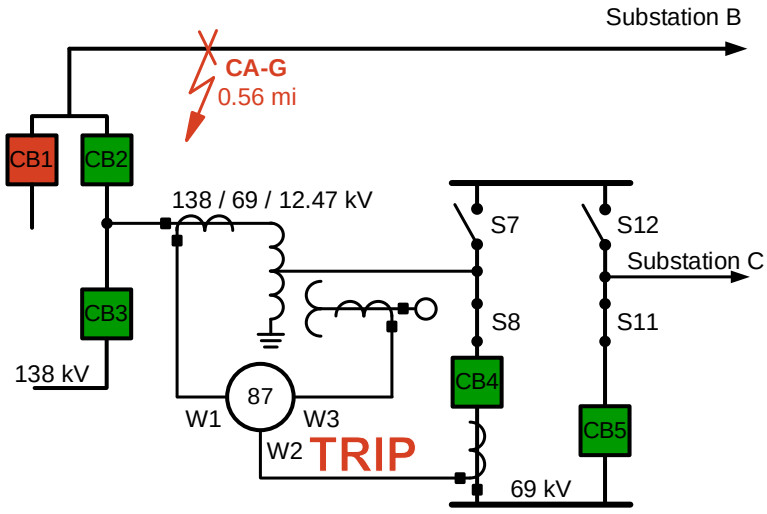
Time – 9:56 a.m.

Fault type – C-G

Cause – Lightning

Result – 87 relay did **not** trip

Fault 4



Date – February 21, 2018

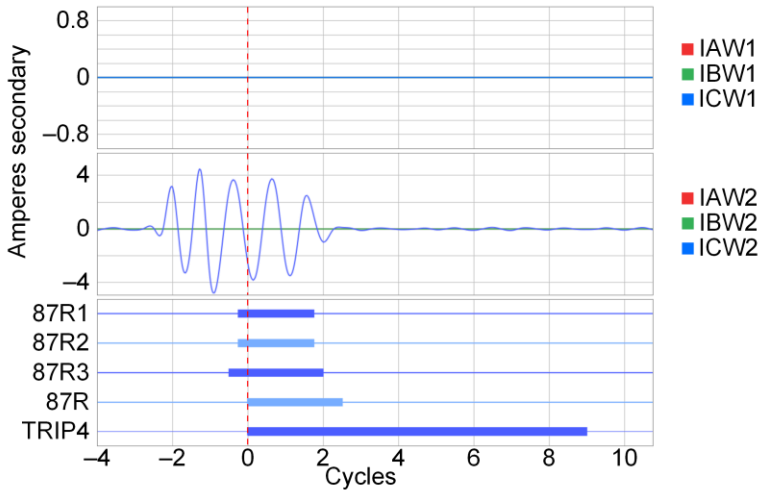
Time – 12:58 p.m.

Fault type – CA-G

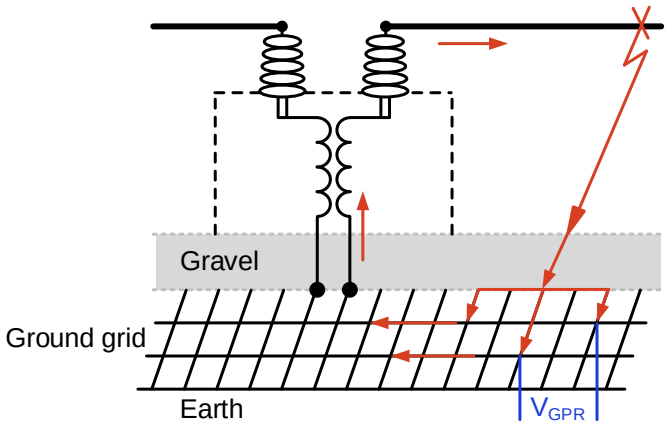
Cause – Lightning

Result – 87 relay tripped on 87R (A-, B-, and C- phase)

Fault 4 event report



Hypothesis – ground potential rise



Grounding recommendations

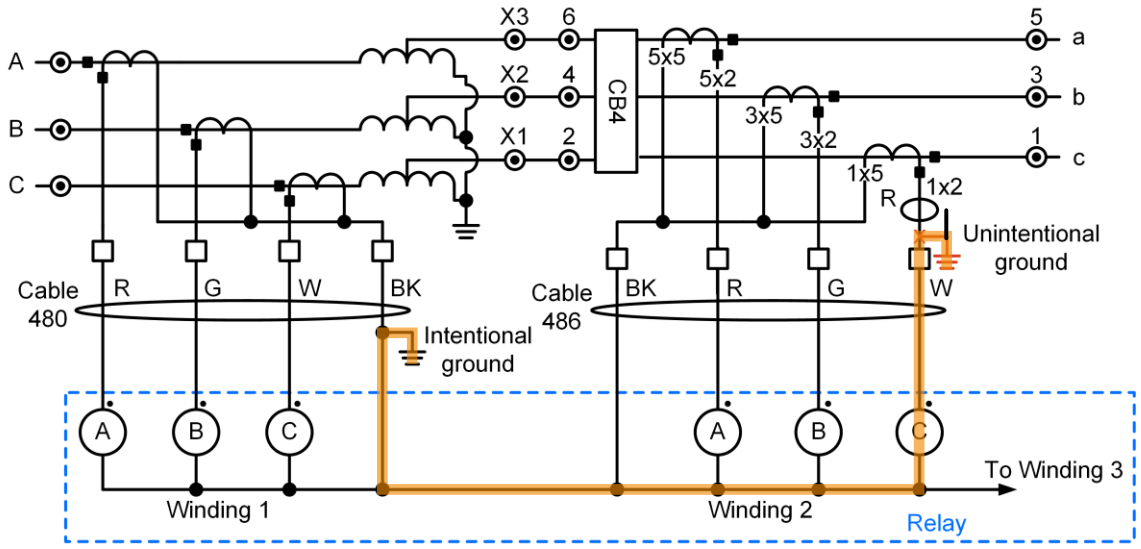
IEEE C57.13.3-2014

- Ground all secondary instrument transformer circuits
- Ground to protect equipment and personnel
- Make only one ground connection per secondary circuit
- Connect secondary grounds at relay panel whenever possible

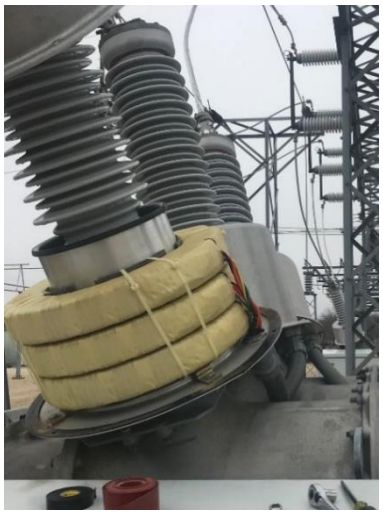
Multiple grounds

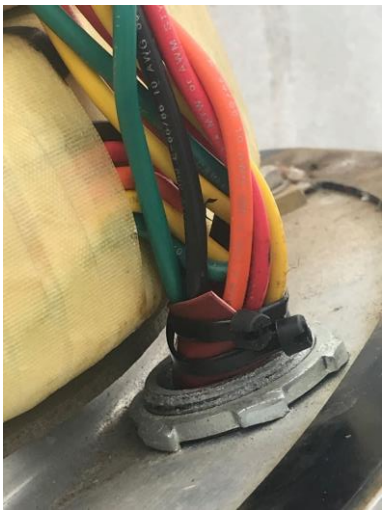
- Hazards
  - Incorrect relay measurement
  - Conductor heating
- Causes
  - Errors in design drawings
  - Accidental field connections
  - Insulation failure

Finding common ground

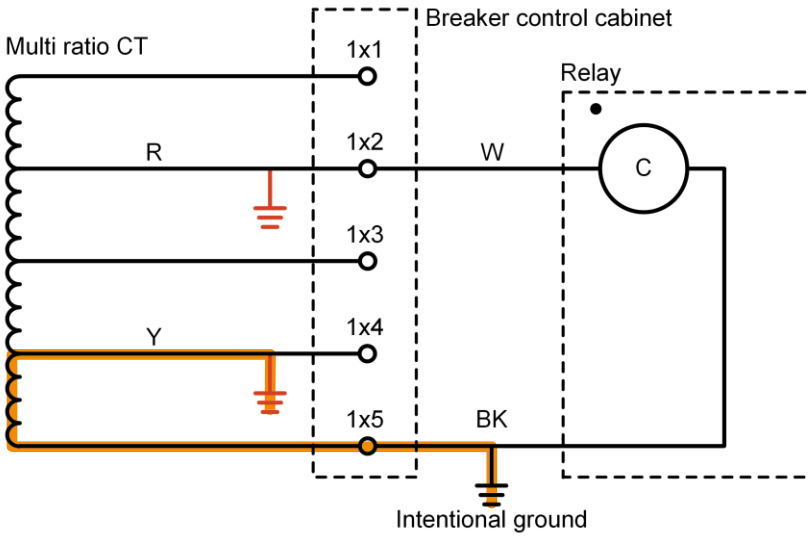


Utility investigation and findings

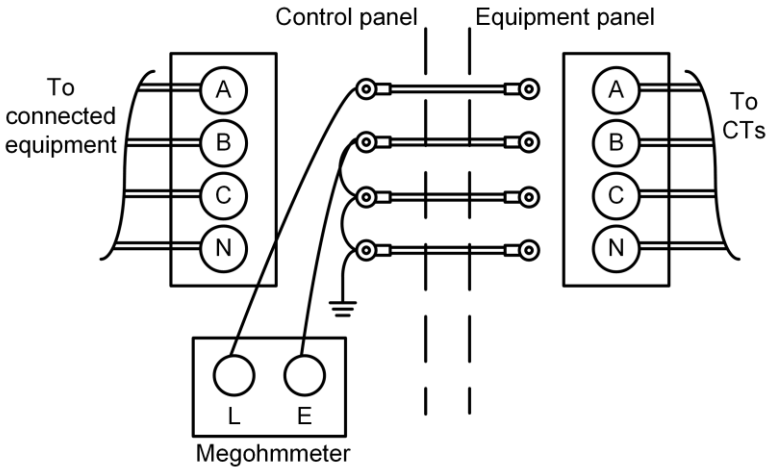




What about the yellow wire?

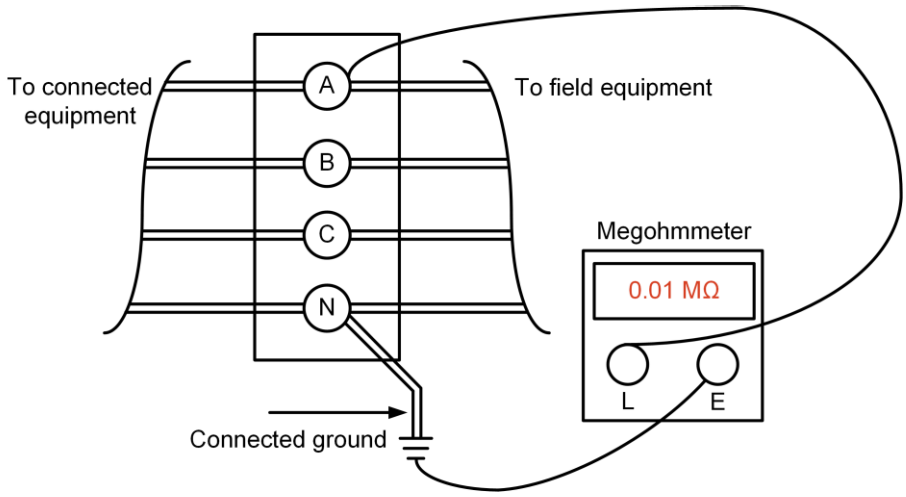


Insulation resistance test

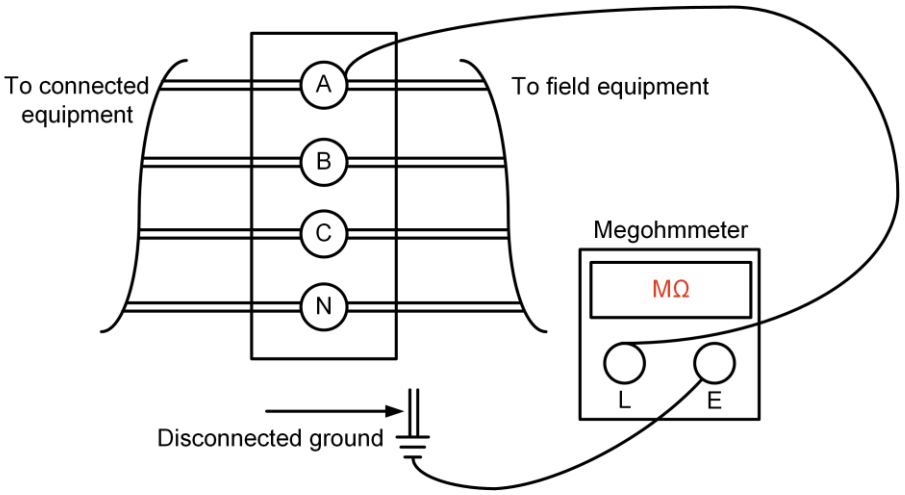


	R (MΩ)	
Length (ft)	600 V Cable	1,000 V Cable
100	16.00	20.00
200	8.00	10.00
300	5.33	6.67
400	4.00	5.00
500	3.20	4.00
600	2.67	3.33
700	2.29	2.86
800	2.00	2.50
900	1.78	2.22
1000	1.60	2.00

Ground / unground test

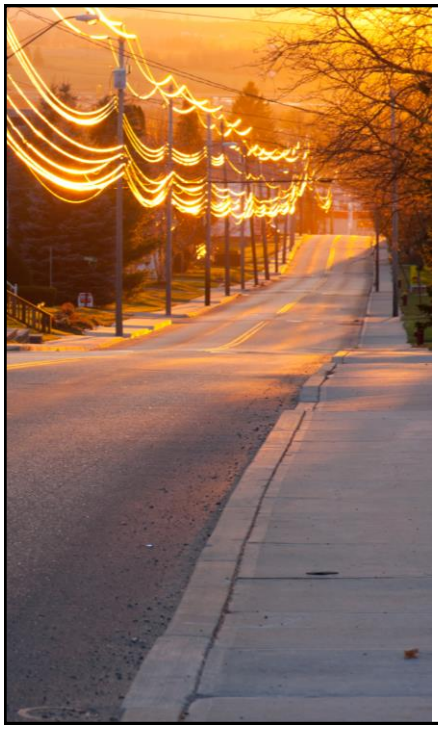


Ground / unground test



Recommendations

- Follow grounding recommendations in IEEE C57.13.3
- Place ground on field side of relay panel terminal block
- In differential circuits, ground each CT circuit individually
- Test for multiple grounds during commissioning and periodic maintenance testing
- Analyze all event reports to identify root cause



Questions?