Line Current Differential Relay Response to a Direct Lightning Strike on a Phase Conductor

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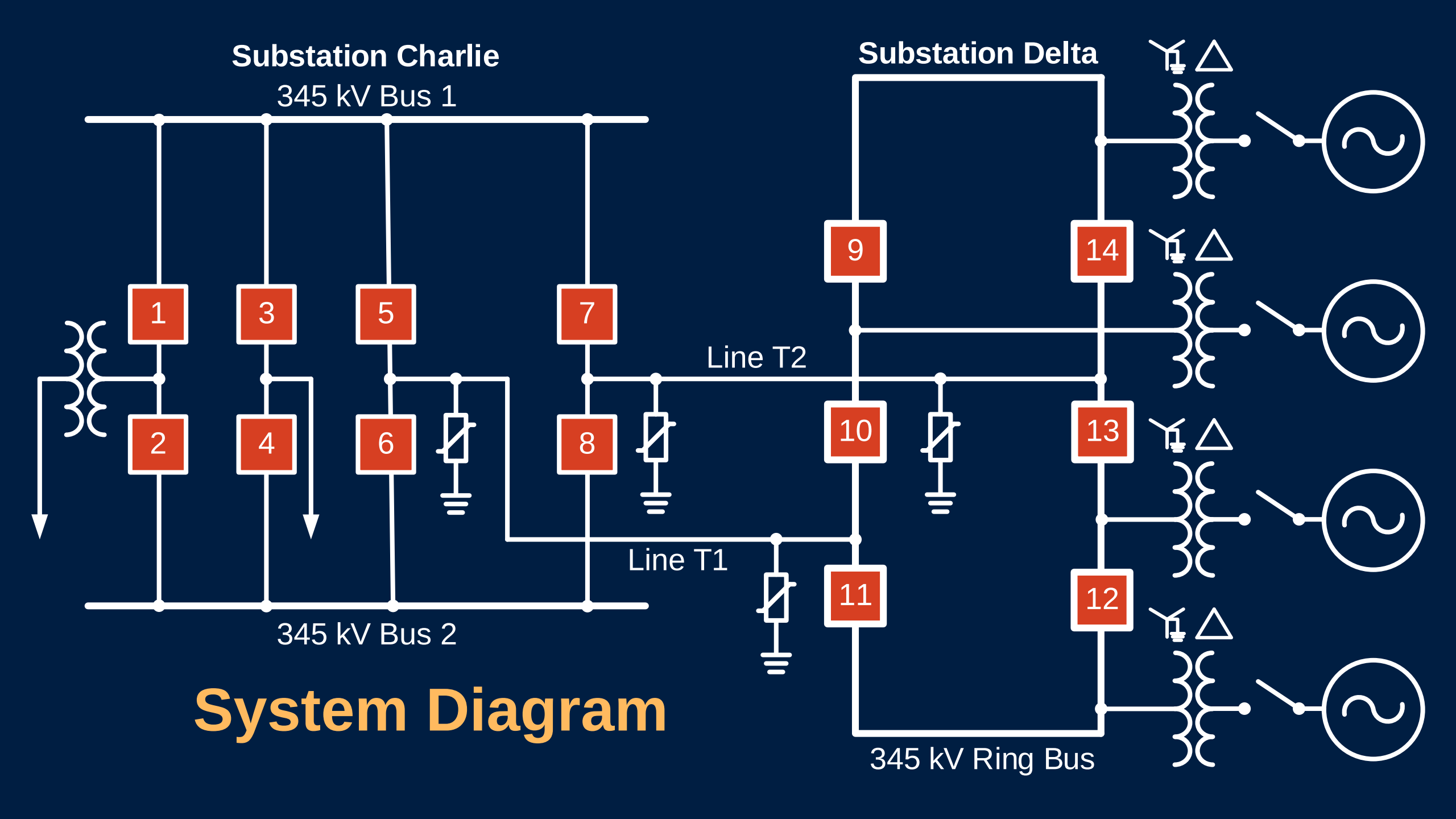
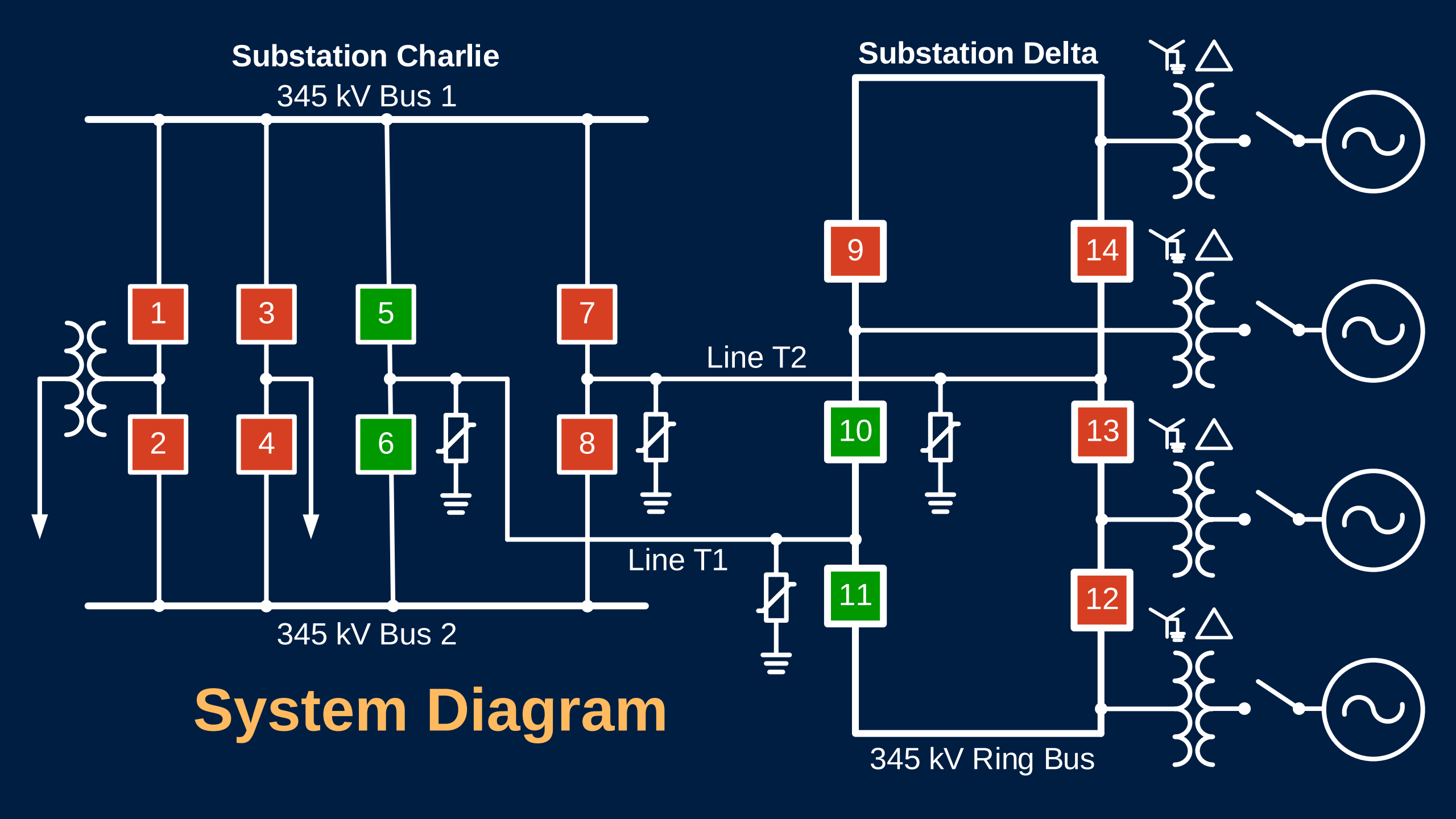

Substation Charlie
345 kV Bus 1
Substation Delta
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Line T2
Line T1
345 kV Bus 2
345 kV Ring Bus
System Diagram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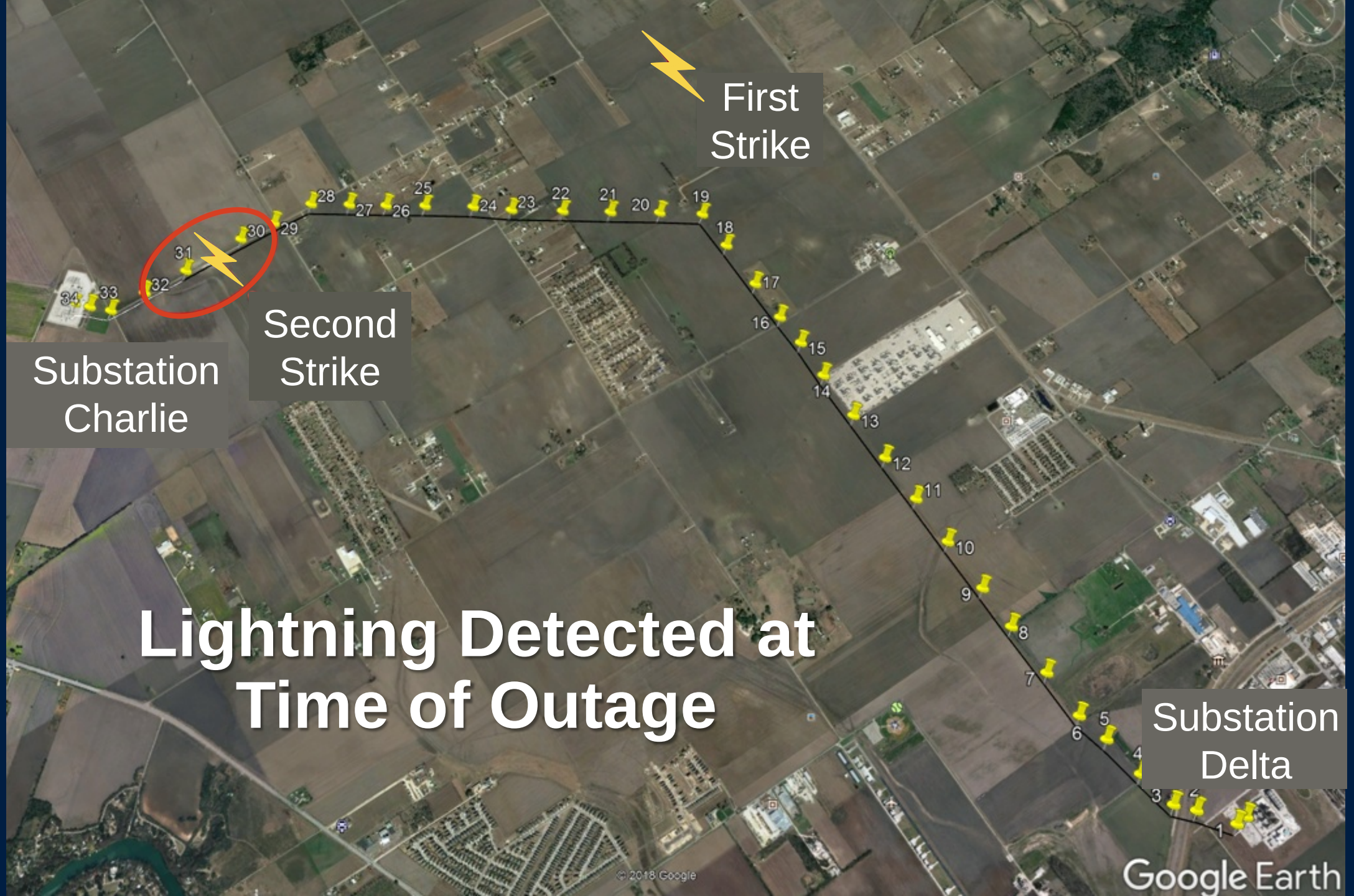
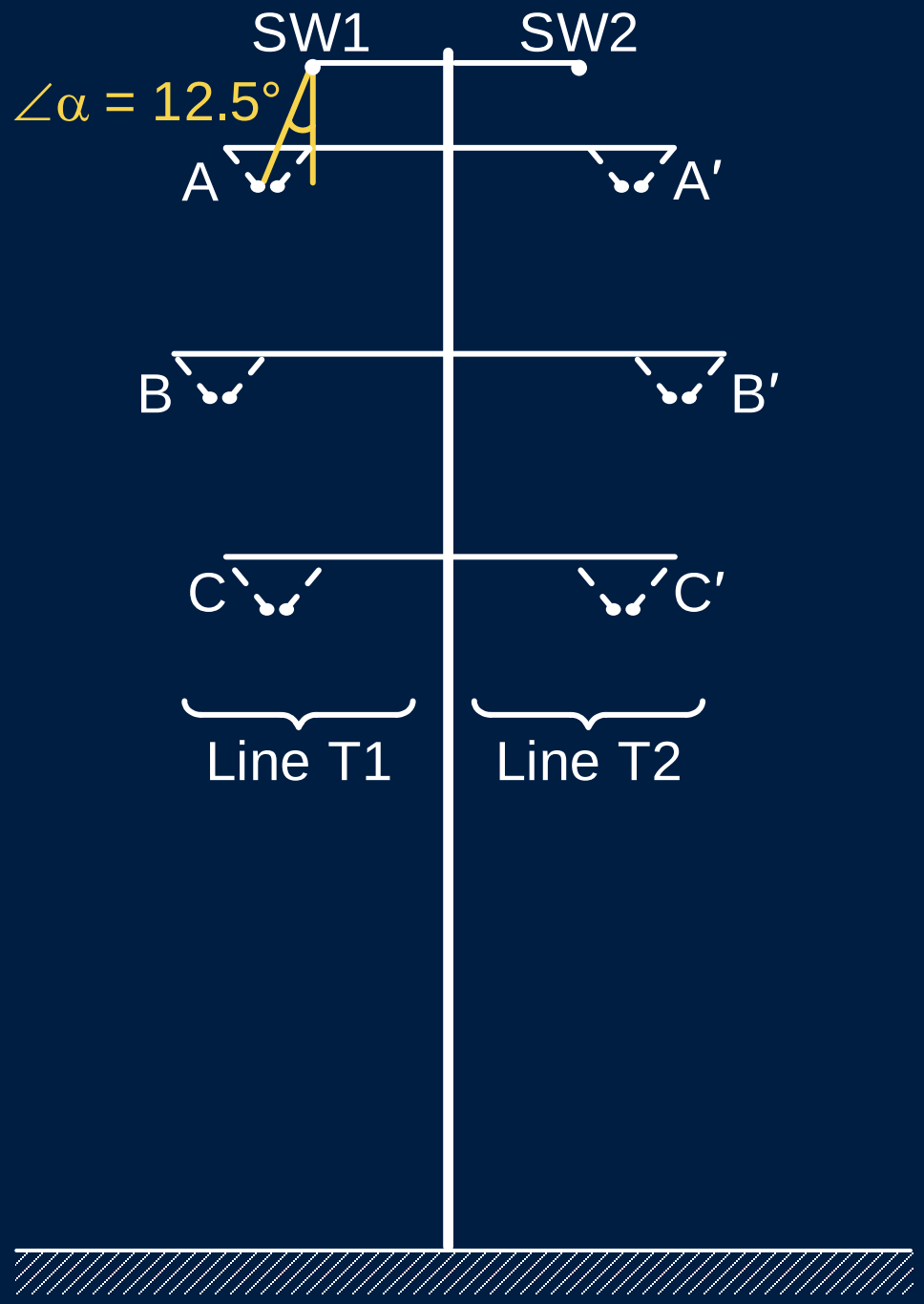
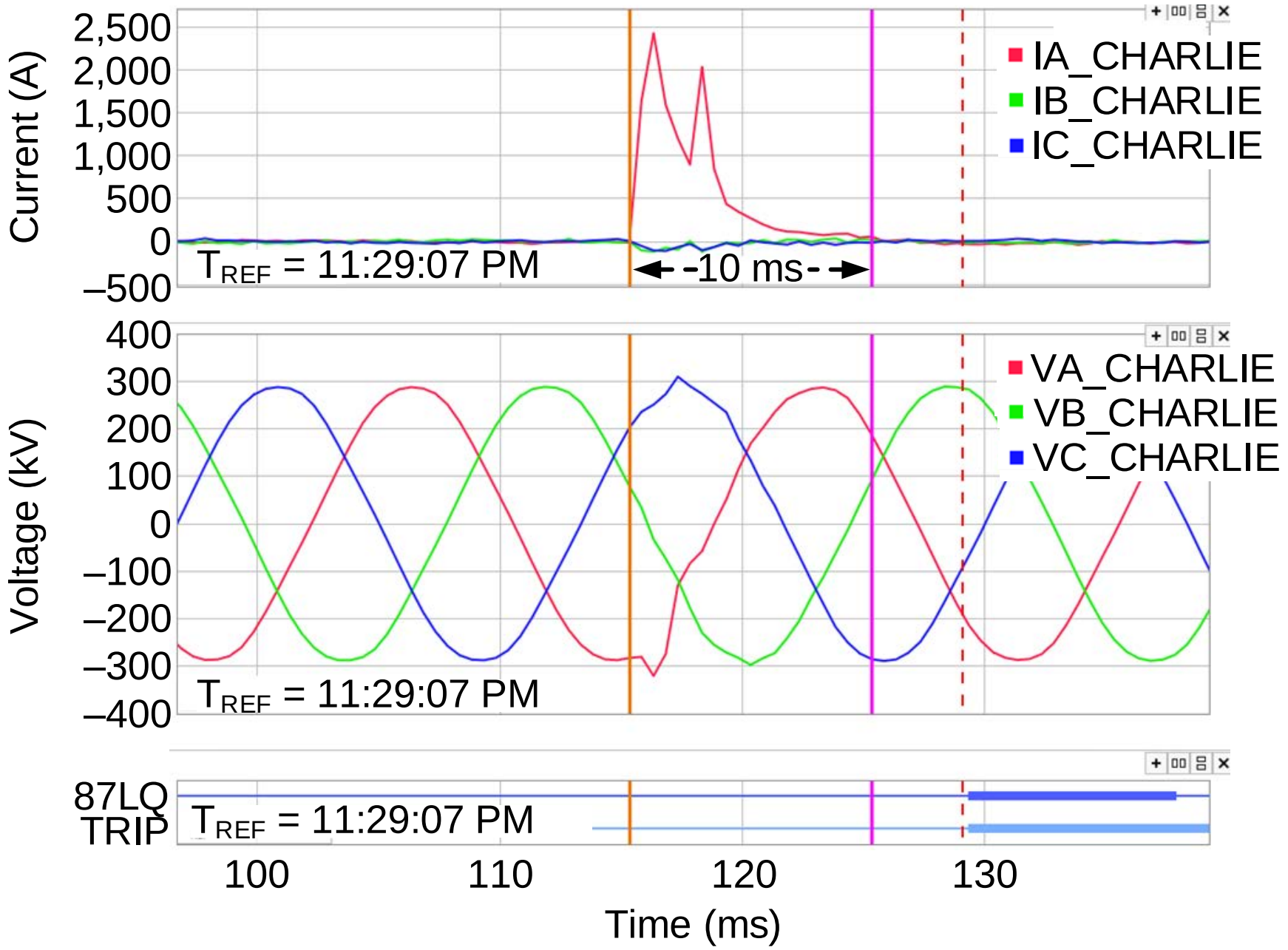
System Diagram


First Strike
Second Strike
Substation Charlie
Substation Delta
Lightning Detected at Time of Outage
© 2018 Google
Google Earth



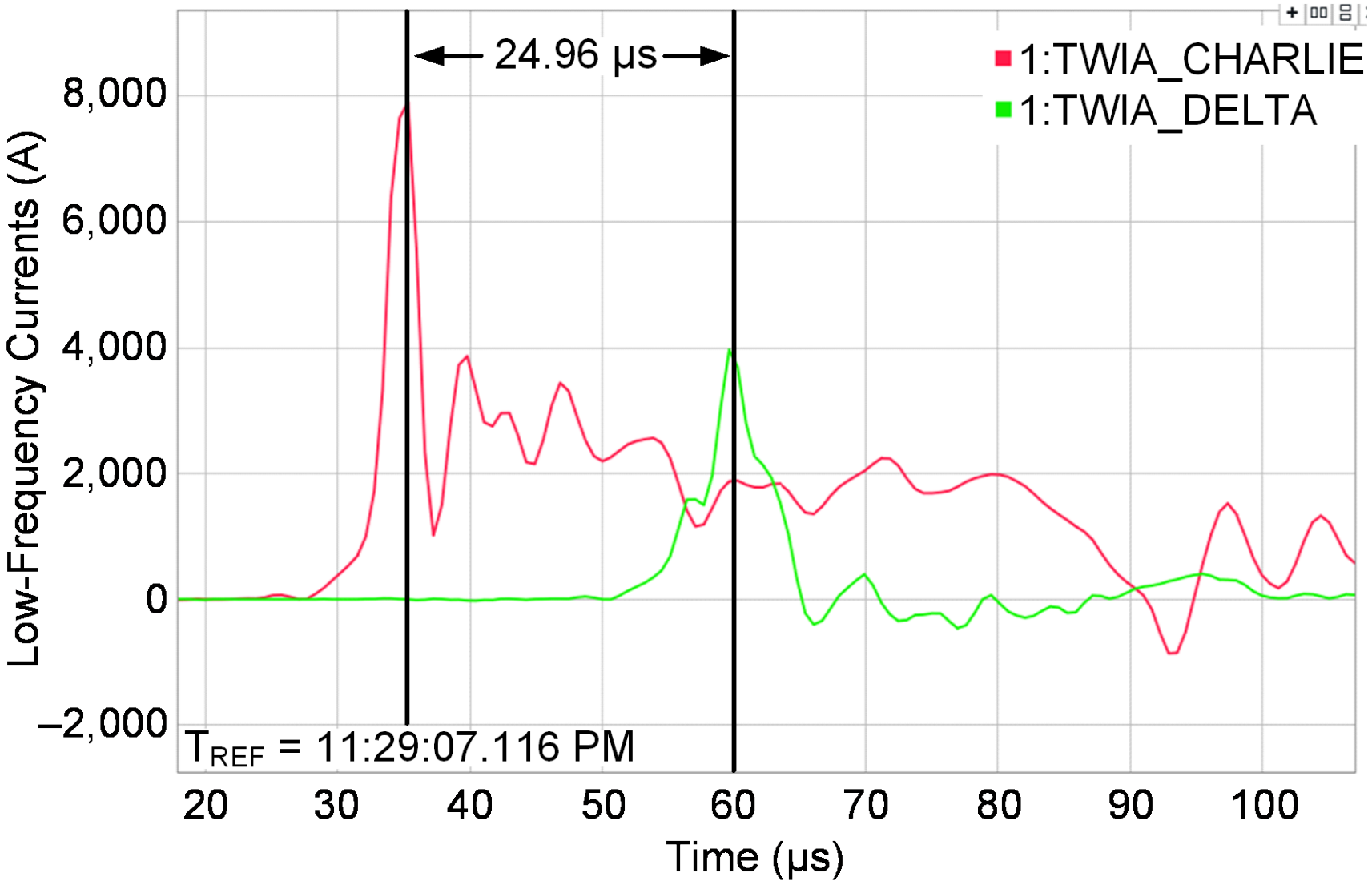
The Mystery Deepens

- Did lightning strike the shield wire or phase conductor?
- Did lightning cause a flashover?
- Was the relay operation correct?

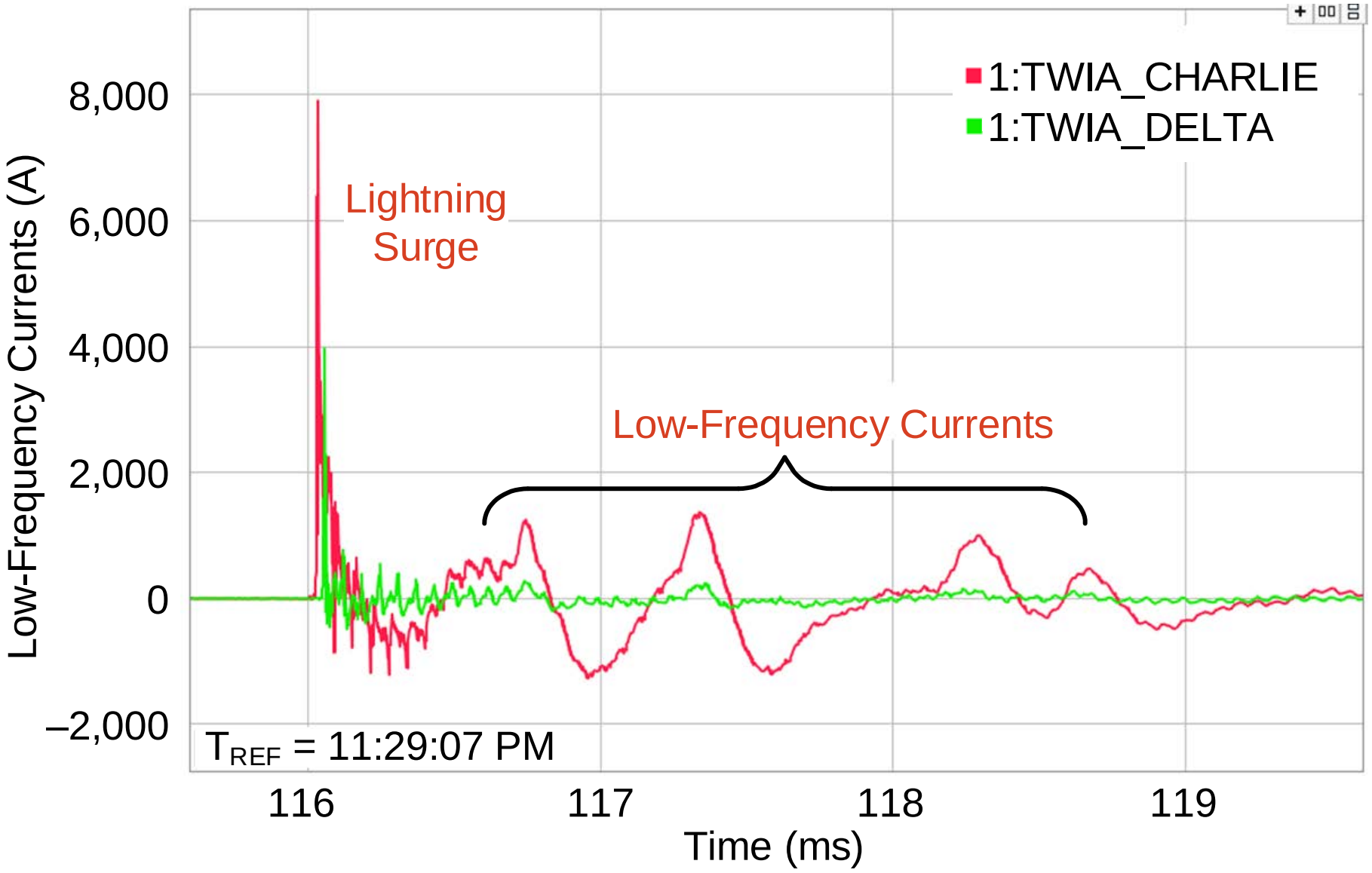


Voltage and Current Increase at Same Time

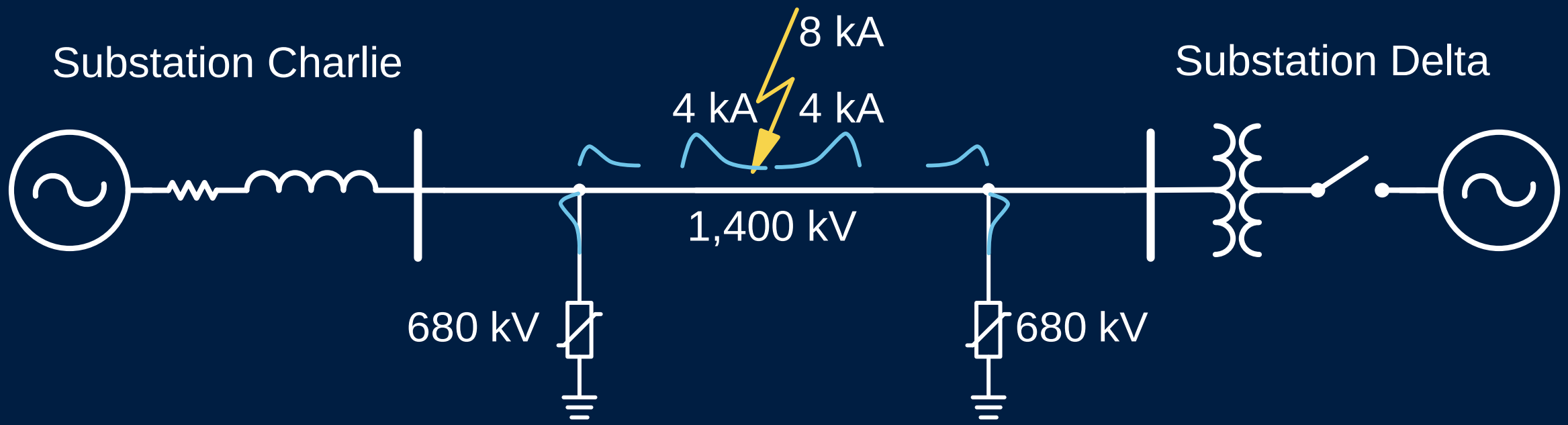
Traveling-Wave Report Confirms Internal Event and Shielding Failure



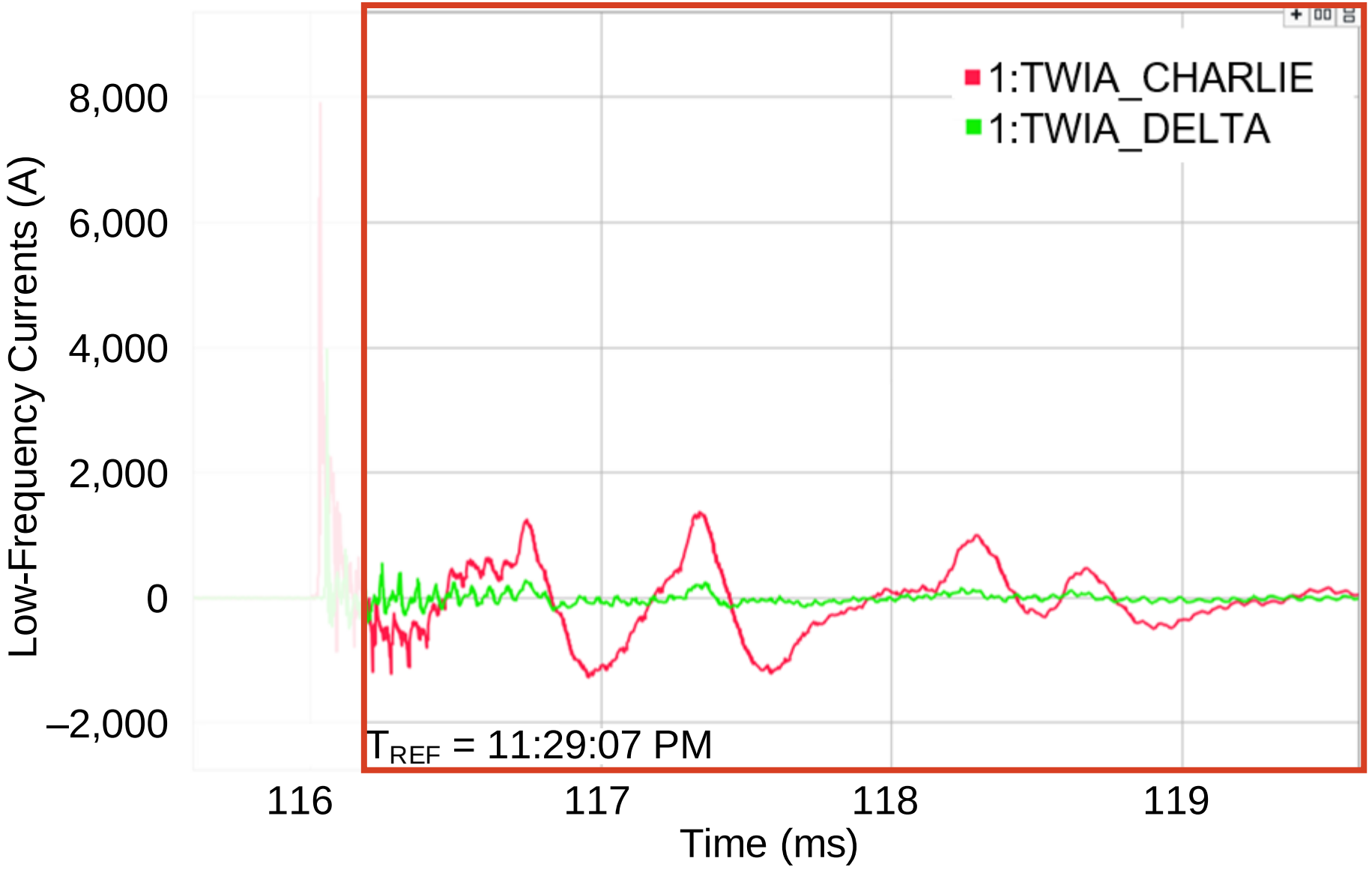
Notice the Low-Frequency Currents?



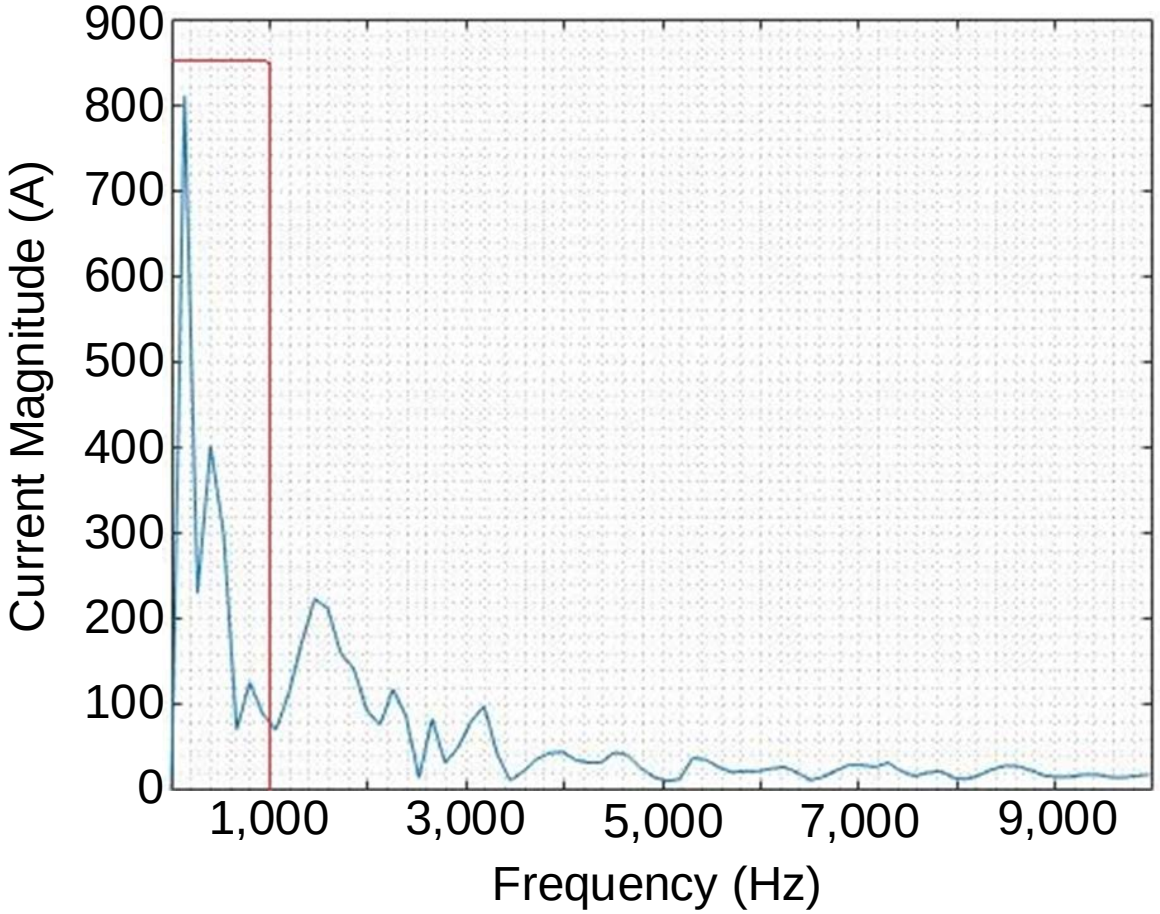
Origin of Low-Frequency Currents

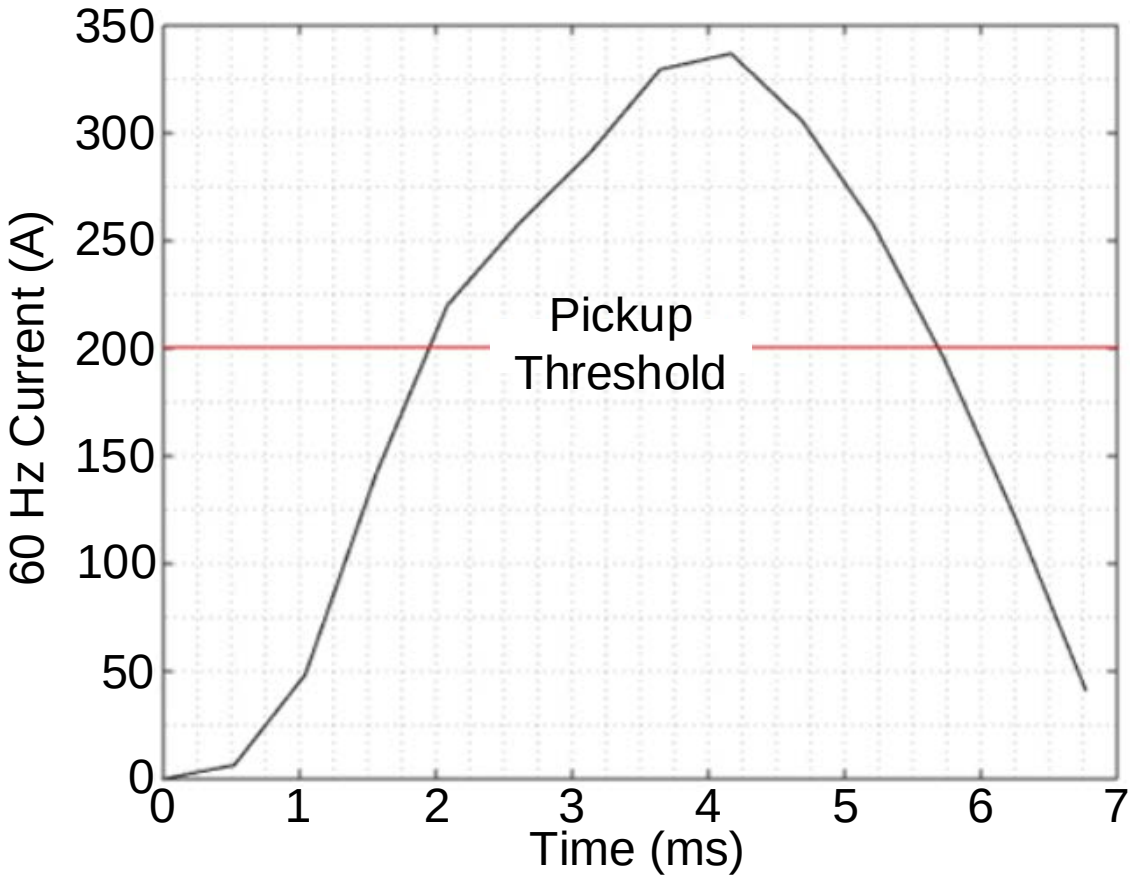


Power System Response to Voltage Step



Frequency Spectrum of Differential Current





Discussion

- Relay operation correct per Kirchhoff’s current law
- No settings change necessary should trip followed by high-speed reclose be considered acceptable response
- If relay action is judged incorrect
  - Increase pickup of negative-sequence differential element
  - Delay element by half or one cycle
- Shielding failure that does not flash over is *rare*

Questions?