PQDashboard User's Group

openXDA Improvements

Probable Fault Cause

Integration with SCADA

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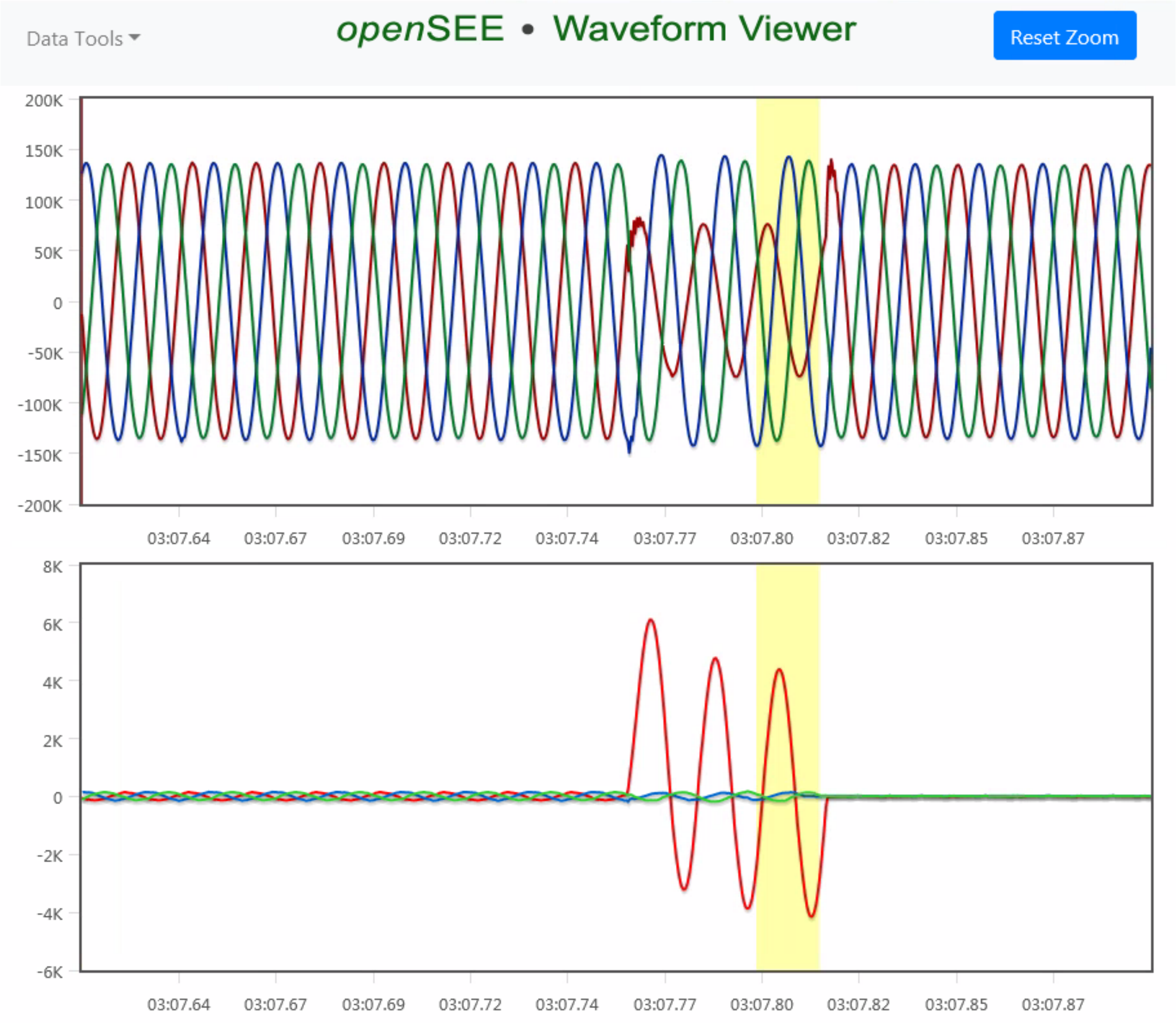
The Candidate Initial Fault Cause Analytics

- Lightning – No waveform analytics. Cause based on time correlation with lightning strike data (Vaisala)
- Conductor Break
- Tree -In-Line
- Conductor Slap / Debris Mid-Line
- Lighting Arrestor Failure
- Insulator Breakdown due to Contamination

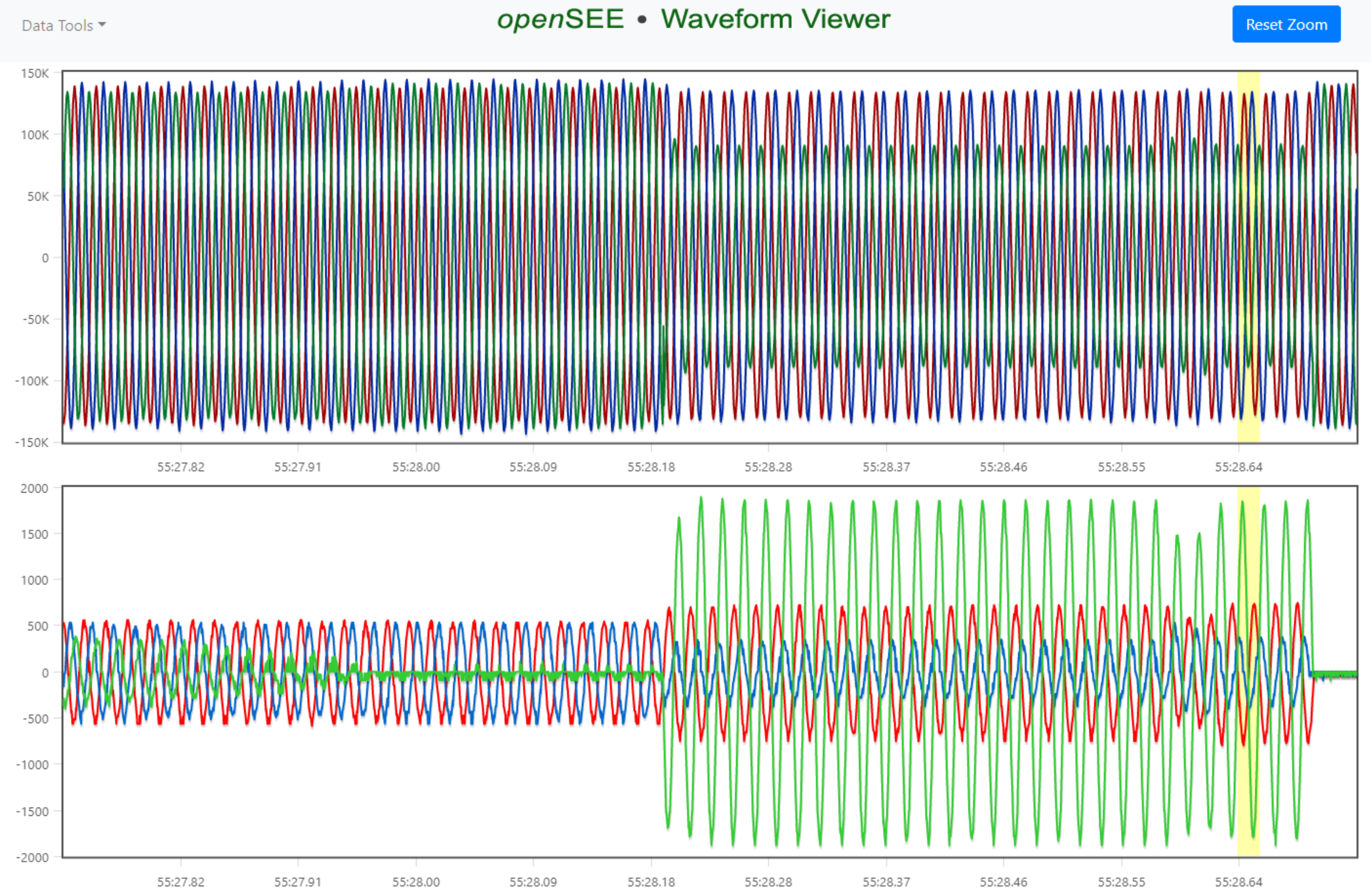
Cause: Lightning

- Approach
  - Query lightning database for lightning strikes in close proximity of faulted line and close time proximity of event
- Observations
  - Only works with access to a lightning database and GIS line data
  - Only tested one case
  - Did not test for false positives



Cause: Conductor Break

- Approach
  - For phase-to-ground faults, check if prefault current disappears in exactly one phase
- Observations
  - 3 out of 5 test cases correctly categorized
  - 2 out of 5 test cases from phase-to-phase conductor break event; prefault current disappears in C-phase, but this violates the phase-to-ground assumption
  - No false positives



Cause: Tree-in-Line

- **Approach**
  - For phase-to-ground faults, check for high fault resistance of tree
  - $$R_F = \sqrt{(X_S D_S)^2 - (X_S D_R)^2} - R_S D_R$$

    where:

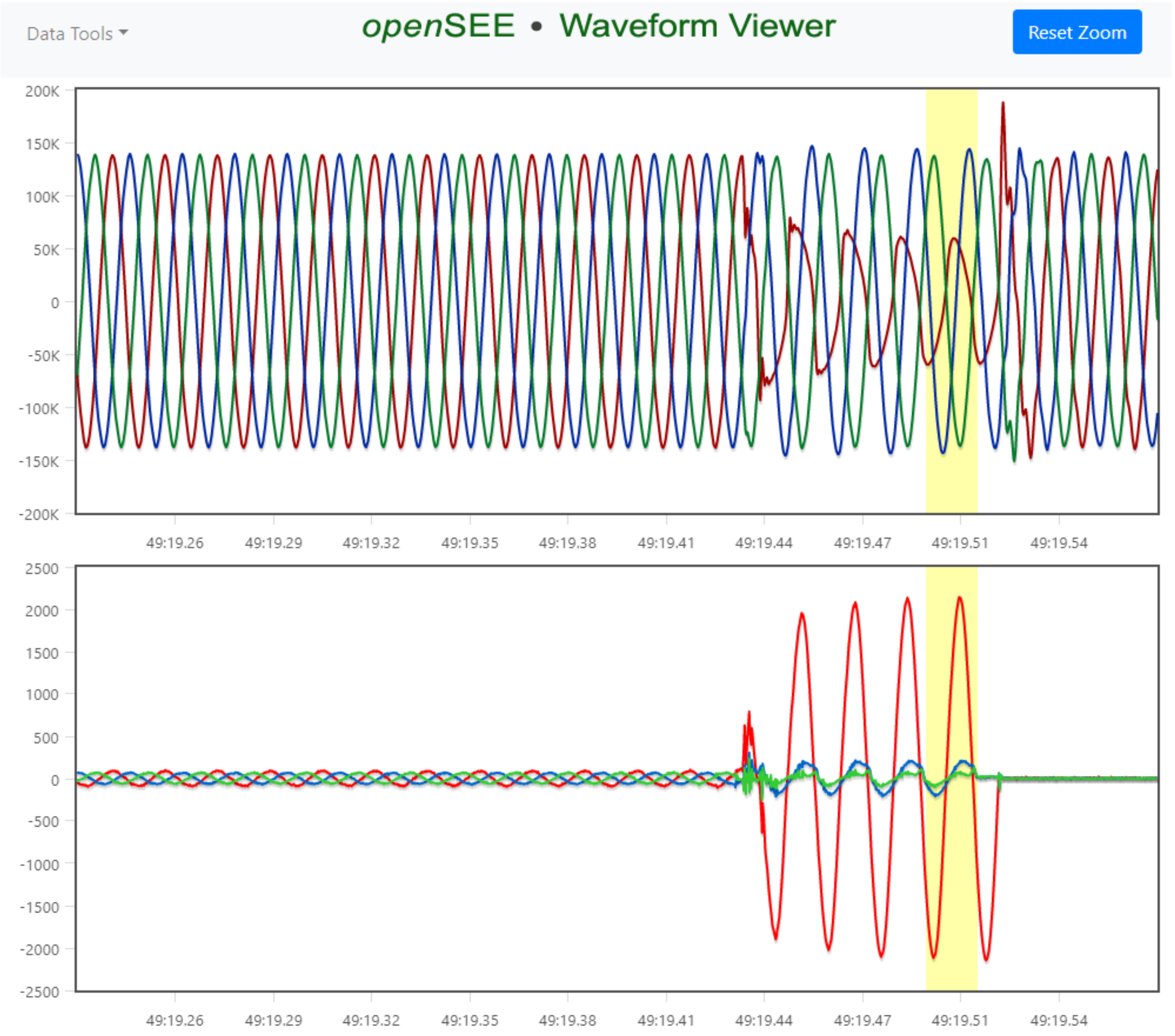
    R_F = Fault Resistance of Tree (Ω)

    R_S = Line Loop Resistance (Ω/mile)

    X_S = Line Loop Reactance (Ω/mile)

    D_S = Calculated Fault Location using Simple Method (miles)

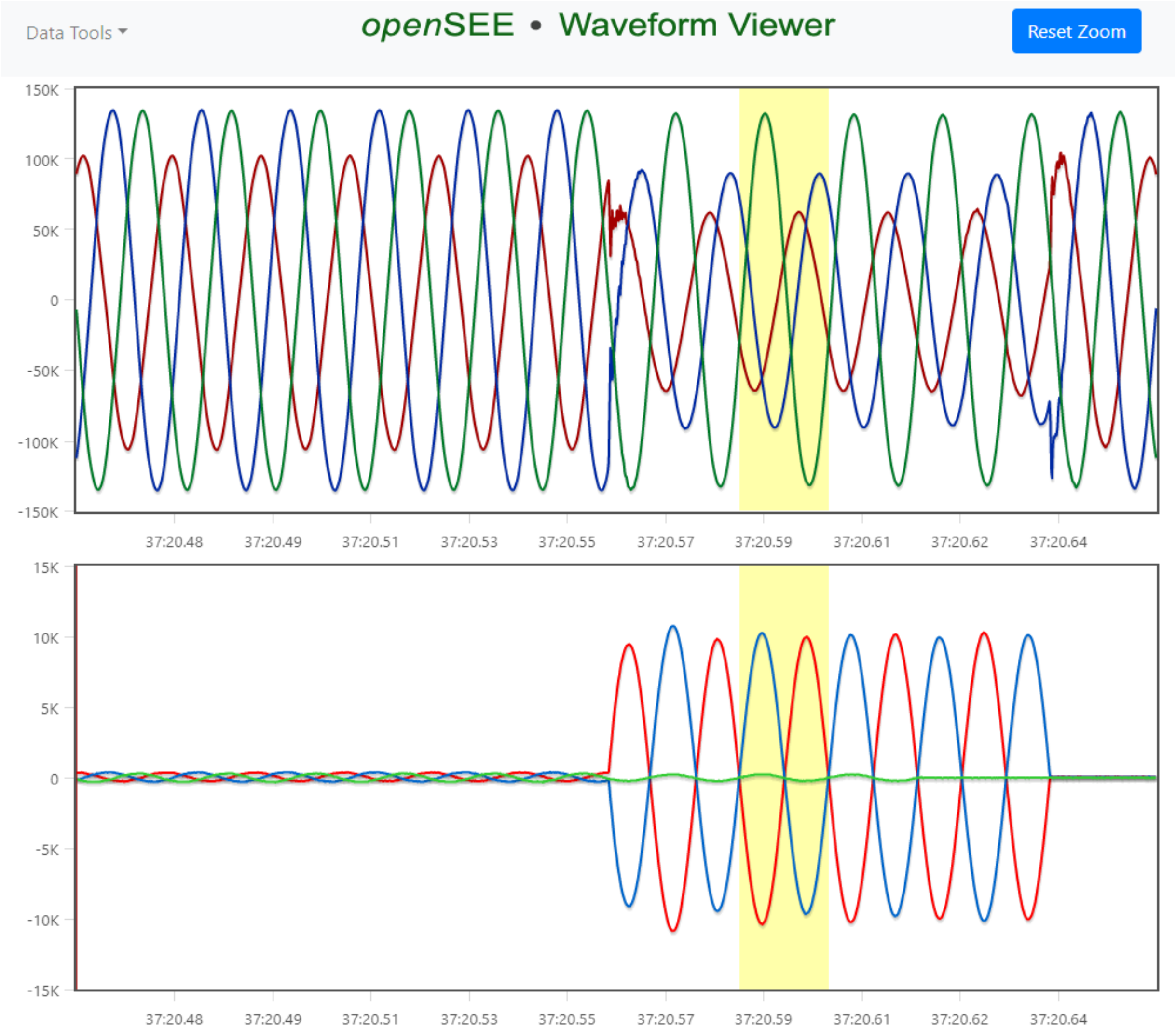
    D_R = Calculated Fault Location using Reactance Method (miles)



- **Observations**
  - 9 out of 9 cases correctly categorized
  - 1 false positive
  - Frequently conflicts with lightning arrestor failure and insulation contamination

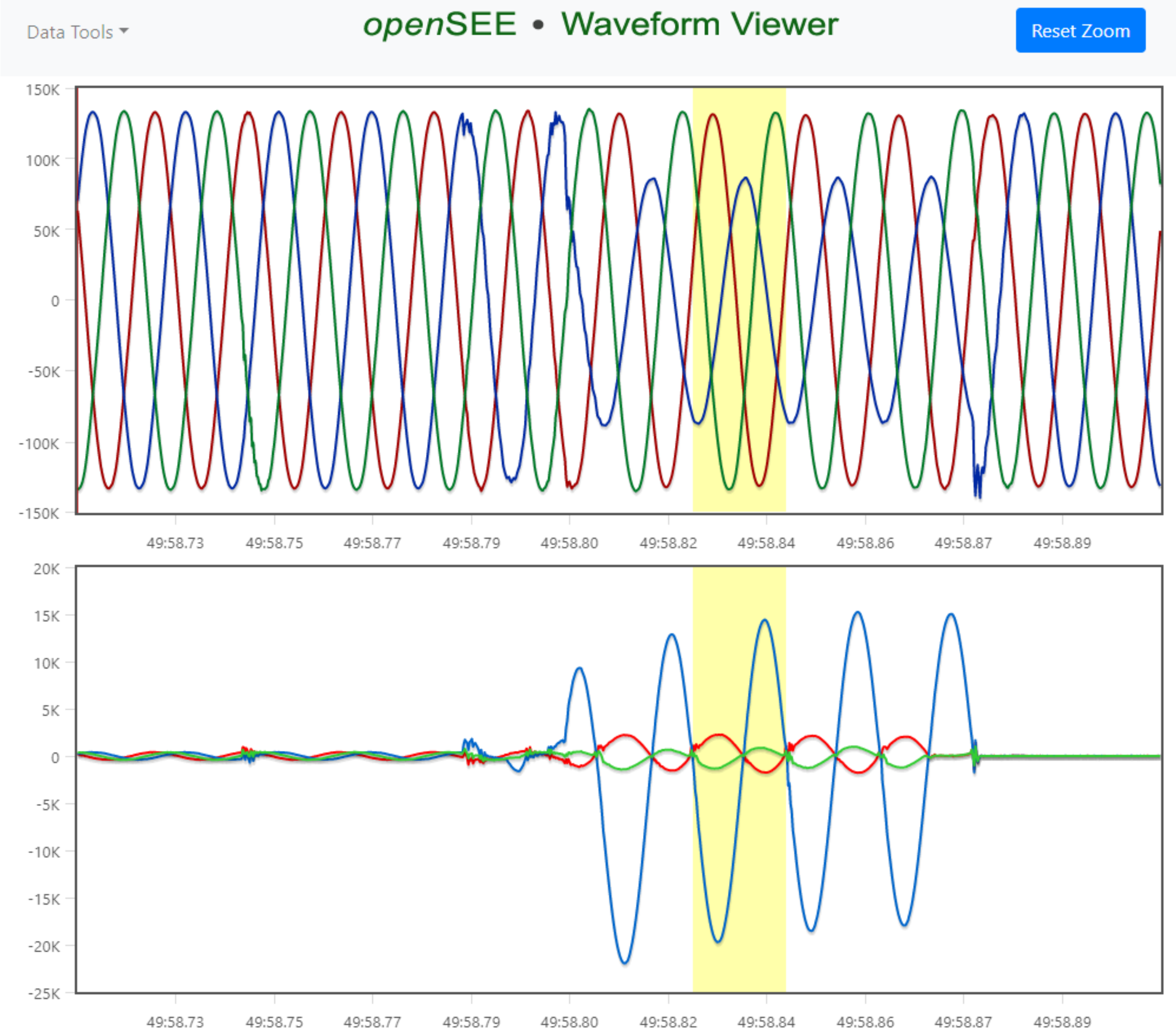
Cause: Conductor Slap / Debris Midline

- Approach
  - For phase-to-phase faults, check for the absence of ground current during the fault
- Observations
  - 6 out of 6 cases of debris correctly categorized
  - 1 false positive
  - Seems accurate, but test library did not contain very many phase-to-phase faults
  - Very little overlap with other fault cause categories (L-L vs L-N)



Cause: Lightning Arrestor Failure

- **Approach**
  - For phase-to-ground faults with prefault load current, check for significant magnitude in third harmonic on current waveform of faulted phase
- **Observations**
  - 3 out of 5 test cases correctly categorized
  - 1 false positive
  - Third harmonic signature does not always appear
  - Accurate fault inception is necessary for this analysis
    - Surge is typically only visible within one cycle of fault inception
    - At point of fault inception, all harmonics spike during wave shape transition



Cause: Insulator Breakdown due to Contamination

- Approach
  - For phase-to-ground faults, check if fault inception is close in proximity to the peak of the voltage waveform
- Observations
  - 4 out of 5 test cases correctly categorized
  - 5 false positives
  - Accurate fault inception is necessary for this analysis
  - Seems to be prone to false positives

Summary – Determining Likely Cause

Cause	Prob. Levels	High Probability
Break	High, Low	Must have pre-fault current and be a L-G fault. High if pre-fault current goes to zero in faulted phase
Lightning	High, Med, Low	Lightning occurs within 2 mSec of fault inception
Tree	High, Med, Low	Must be a L-G fault. “Fault resistance” is >= 20 ohms
Slap/Debris	High, Low	Must be a L-L fault. Ratio of ground current to fault current < 0.3
Arrestor	High, Low	Must have pre-fault current and be a L-G fault. Ratio of third harmonic to first harmonic for pre-fault current > 10%
Insulator	High, Med, Low	Must have pre-fault current and be a L-G fault. Phase shift pre-fault to fault-inception +/- 15 degrees.

Decreasing Analytic Certainty

Likely cause = only one ‘high probability’ found → display cause
= multiple ‘high probability’ found → display cause with most certainty and “?”
= no ‘high’ and one or more ‘medium’ found → display cause with most certainty and “??”
ELSE display cause as “unknown”

Interesting Summary Data: Unknown Cause

- Actual cause reported was conductor break
- Start of waveform indicates conditions for conductor break with no current on C-phase
- Anomaly on B-phase occurs
  - Fault analysis classifies as AB
- Load current disappears (did the breaker open?)
- New fault occurs several cycles later
  - Fault analysis classifies as BC

Interesting Summary Data: False Positive Cause

- Actual cause: insulation contamination
- Inception was wrong because the fault occurred as the sine wave was decaying so the total fault amplitude could not be observed until the next half-cycle
- Using the correct fault inception, fault would be classified as Unknown

Next Steps To Improve Fault Cause Determination

- Refine and test current analytics with multiple more test cases.
  - Tune parameters
- Improve algorithm for fault inception determination
- Add binary signature attributes to fault results to add insight into cause and/or be part of future cause determination analytics
  - Arcing?
  - Bolted?
  - High Resistance?
  - CT saturation?
  - Waveform clipping?
  - Fero-resonance?
- Add more cause analytics ("smoke" coming soon)

Integration with SCADA – openXDA Version 2.4

- Problem Statement
  - Need to reduce false positive faults detected by openXDA

- Solution
  - Integrate with SCADA data to validate breaker operation

openXDA detects fault

Query SCADA Historian for a time window – e.g., inception time +/- 30 seconds

Did any breakers for this line state change to “open” within this time window?

Yes == Valid Fault