Voltage Transformer Failure Prediction With Synchrophasor Data

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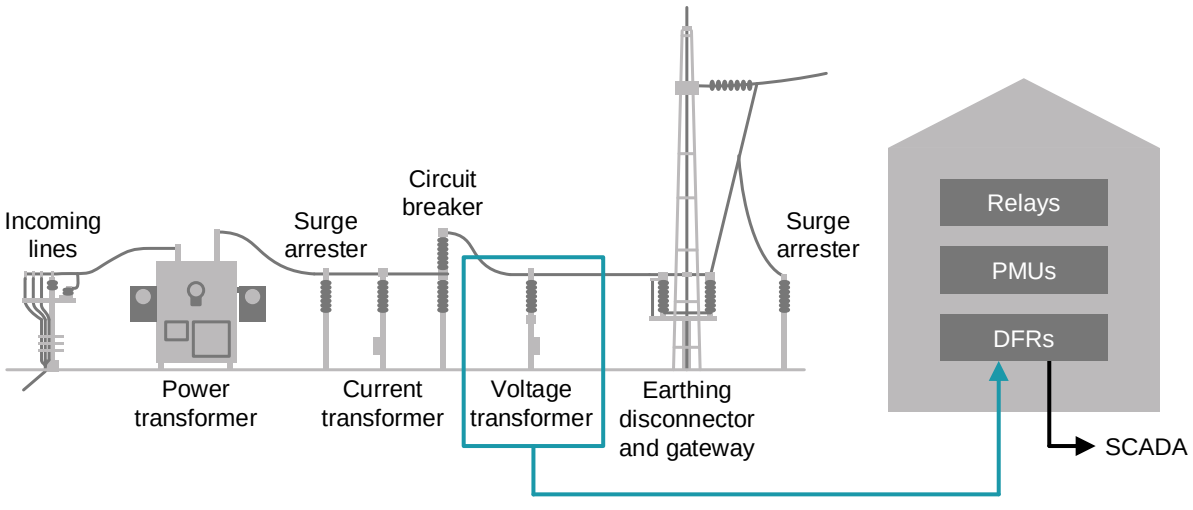
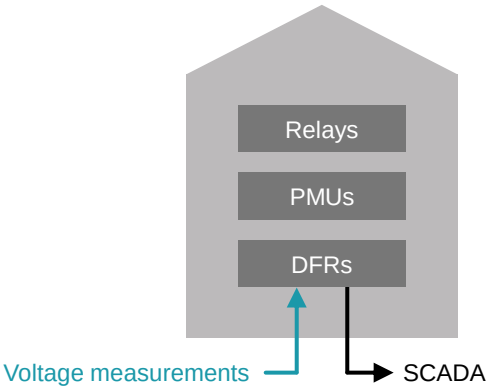
Prevent equipment failure

Voltage transformer



Potential impacts of failing voltage transformer

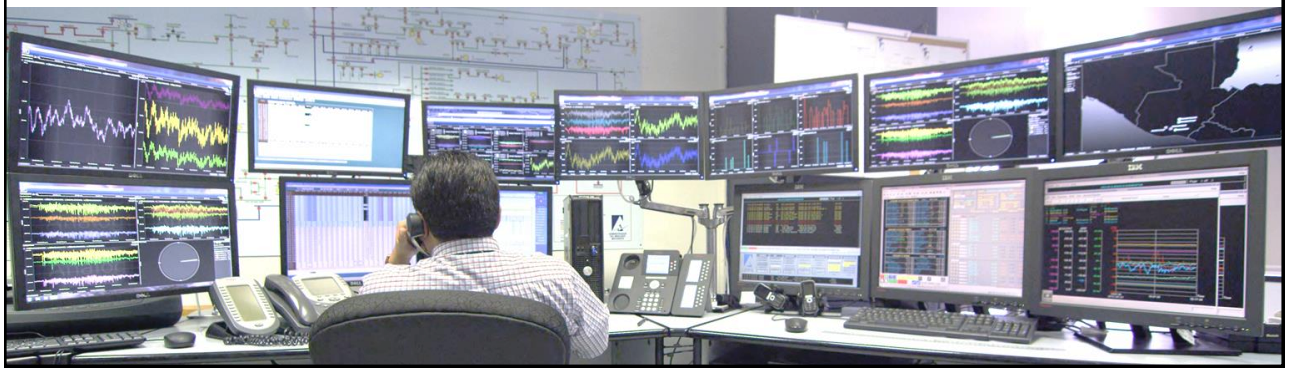
- Protection impacts
  - Improper relay operation
  - False alarms sent to SCADA
  - Misrepresentation of phase angle
  - Corrupted voltage measurements
  - Corrupted frequency signals
- Equipment/personnel impacts
  - Substation equipment damage
  - Personnel safety hazards



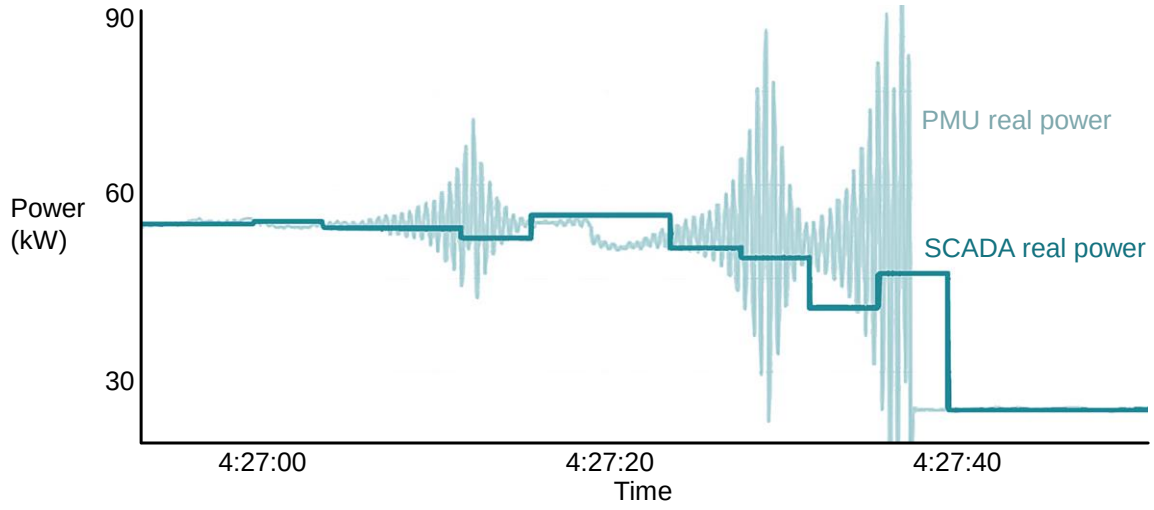
Existing detection methods

Loss-of-potential logic in protective relays

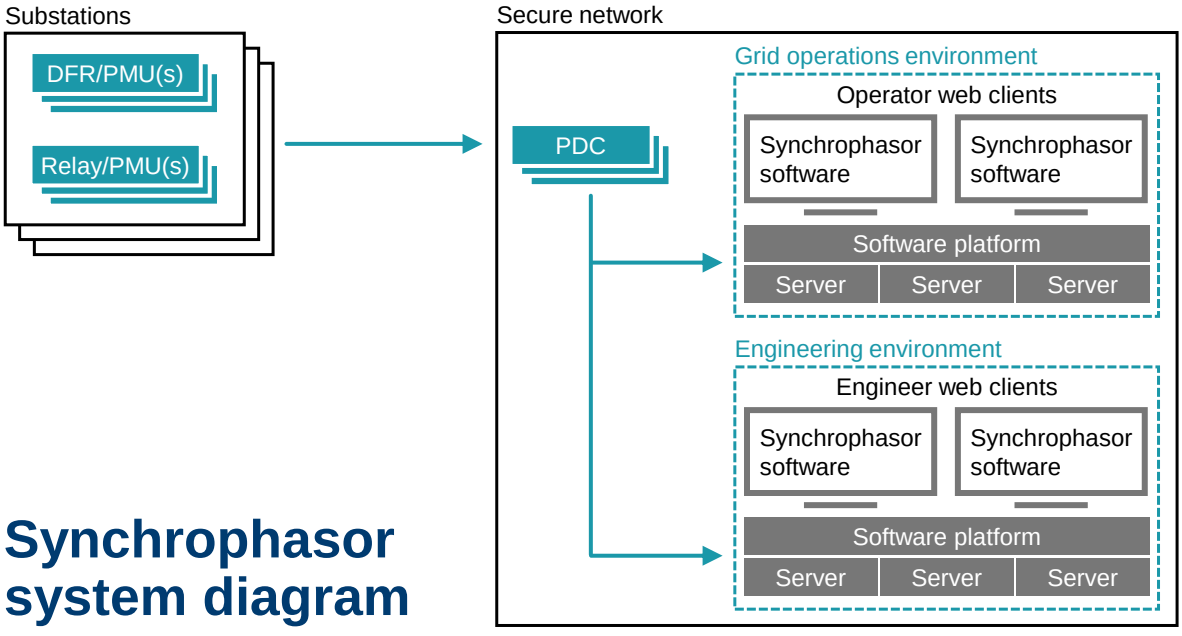
SCADA-based protection



SCADA misses information

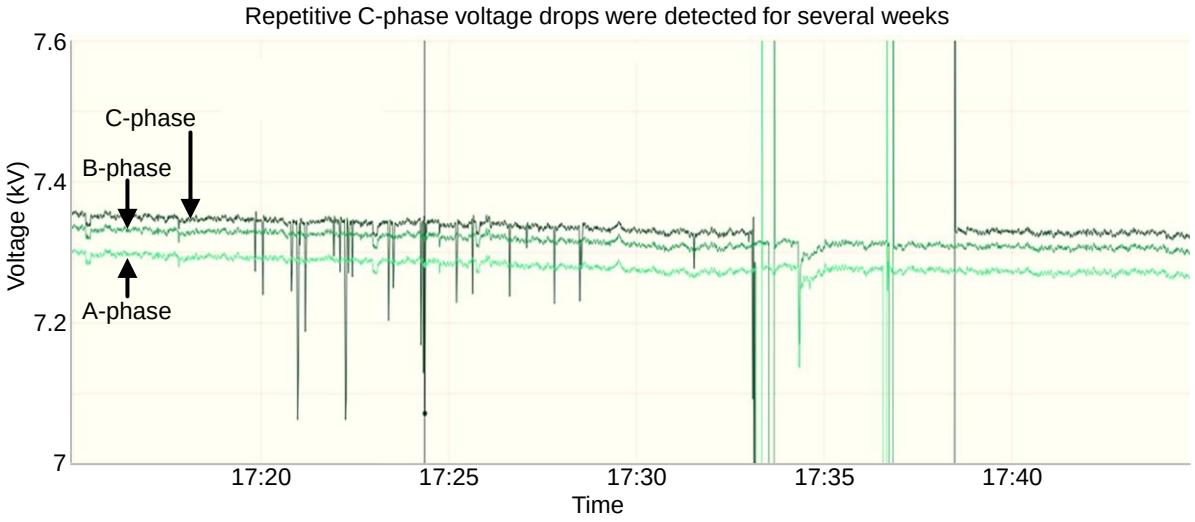


Synchrophasor system diagram

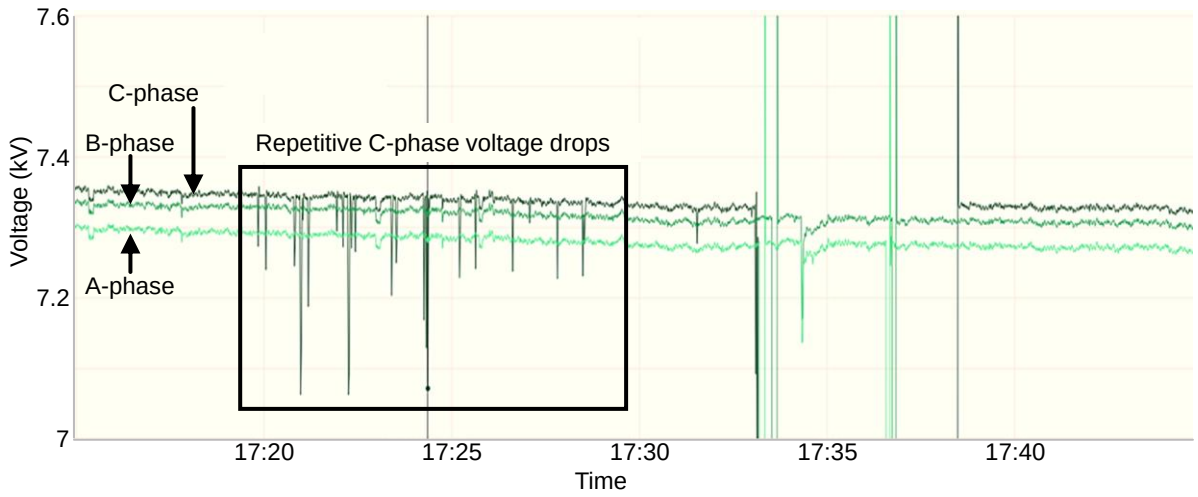


Situational awareness software user interface

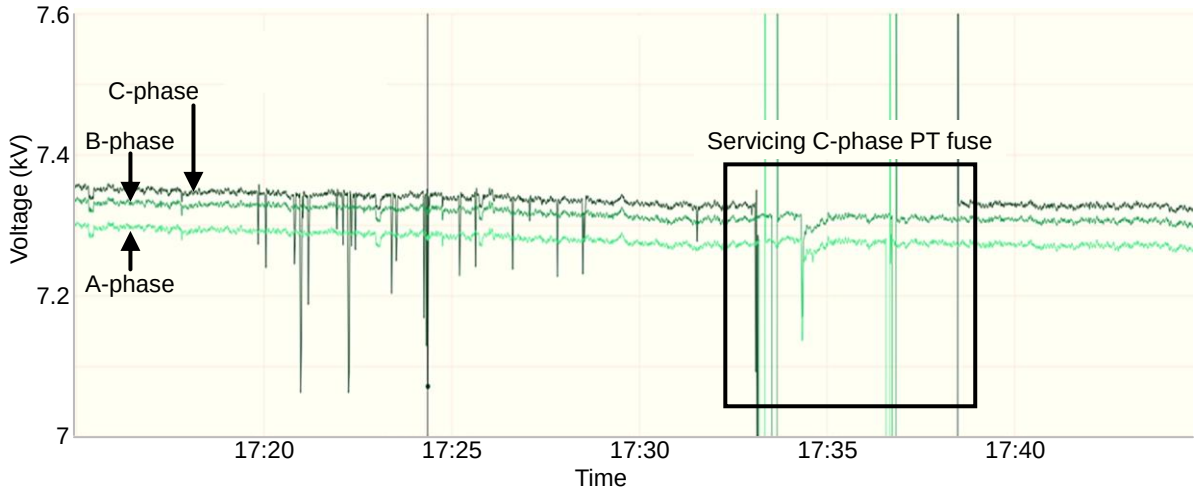
First voltage transformer failure



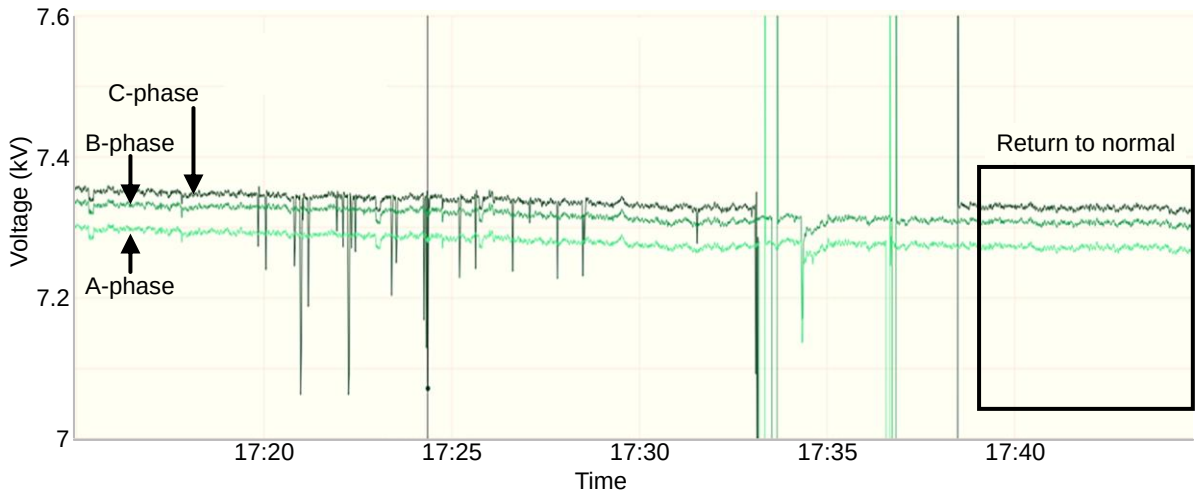
First voltage transformer failure



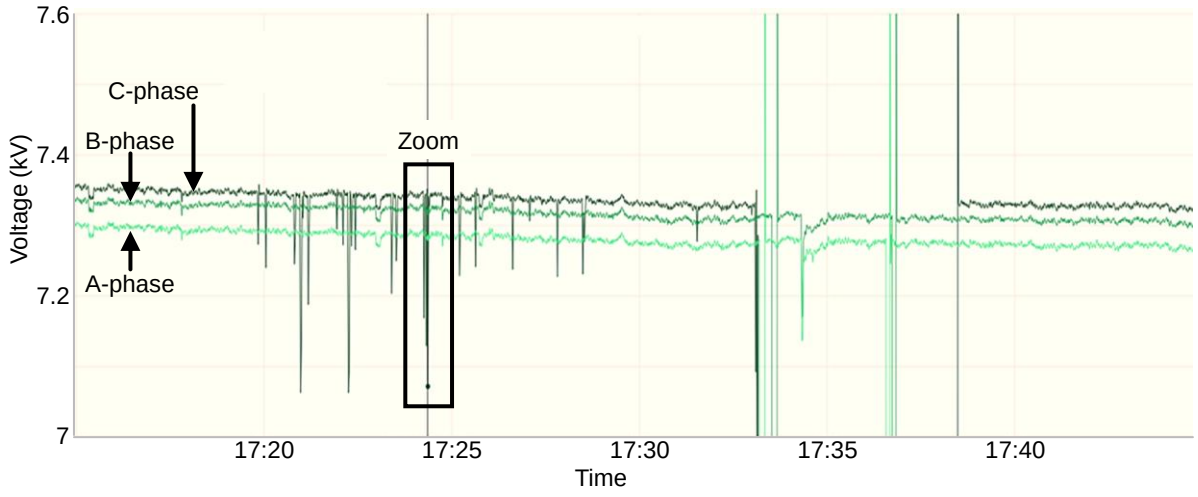
First voltage transformer failure



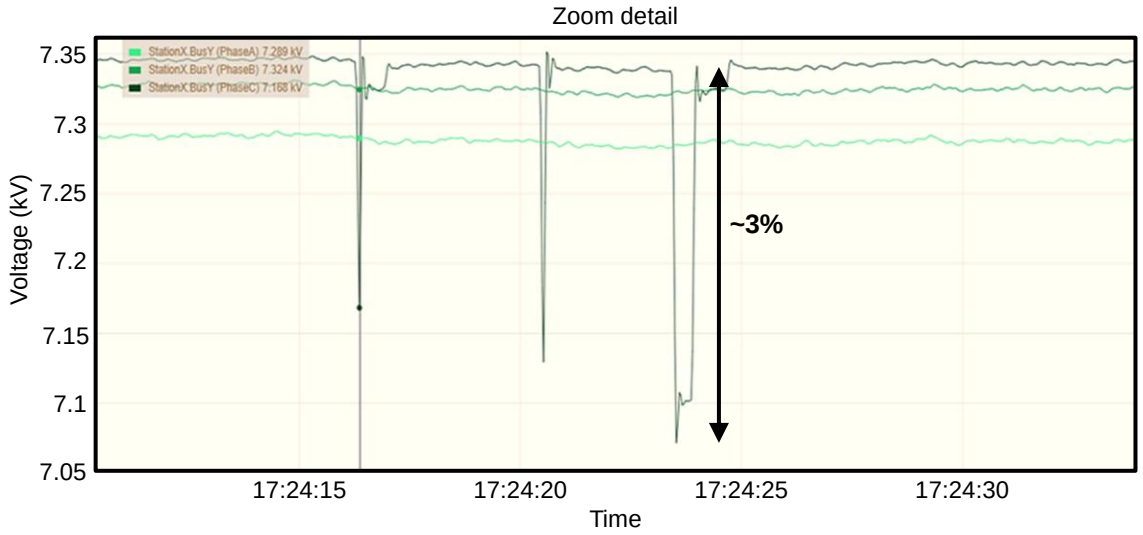
First voltage transformer failure



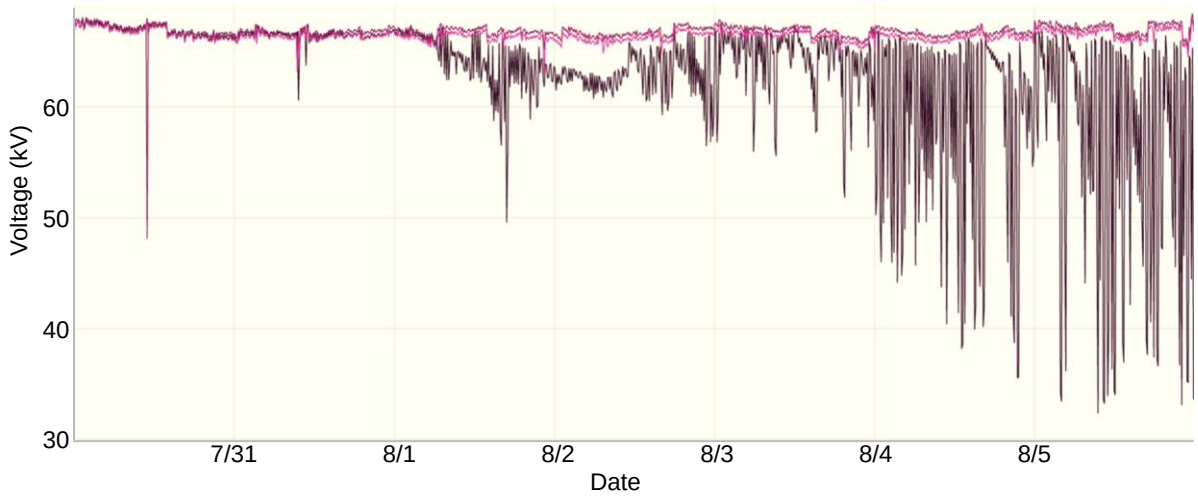
First voltage transformer failure



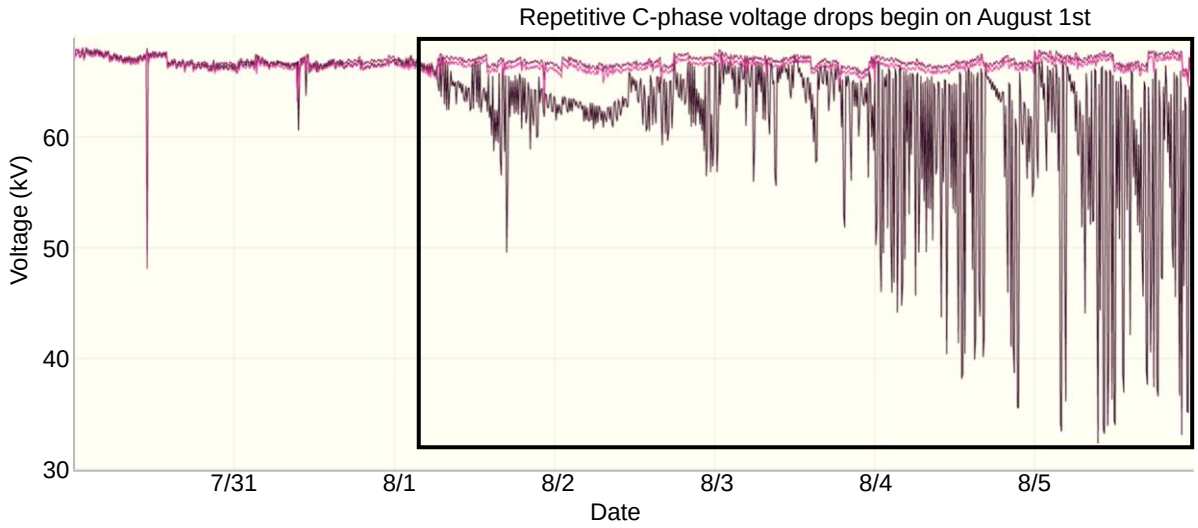
First voltage transformer failure



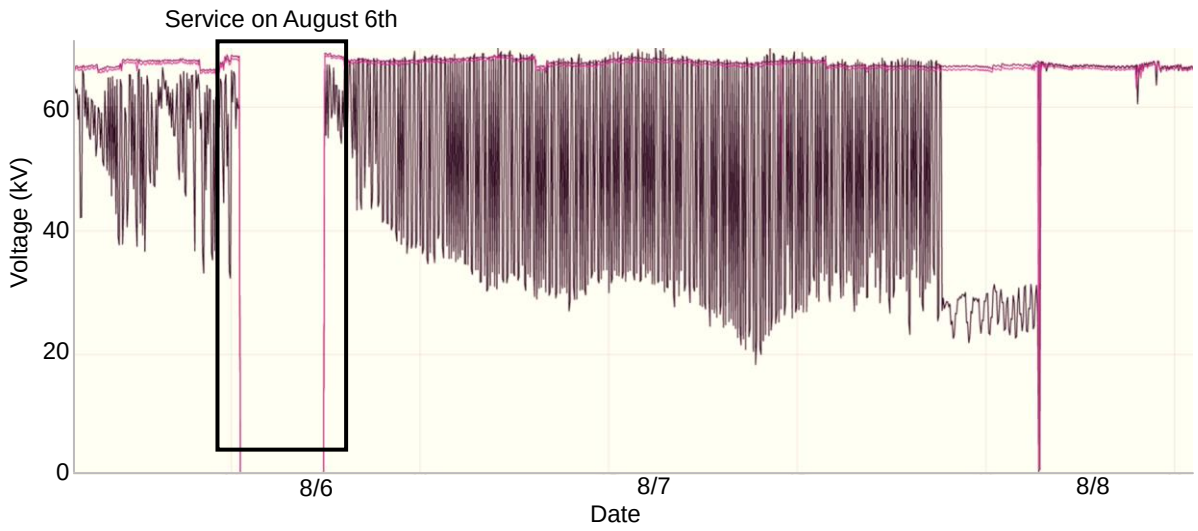
Second voltage transformer failure



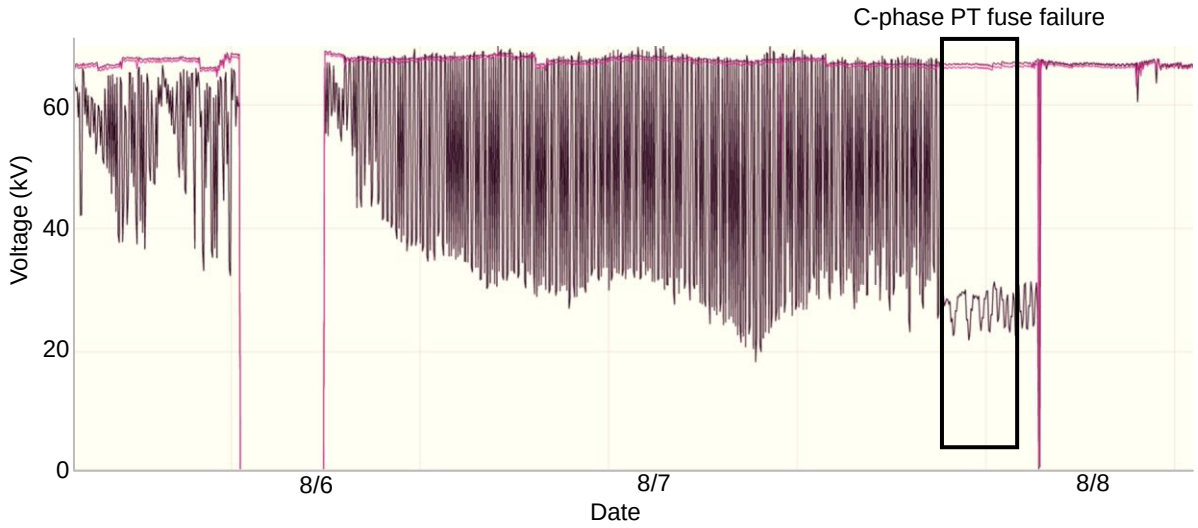
Second voltage transformer failure



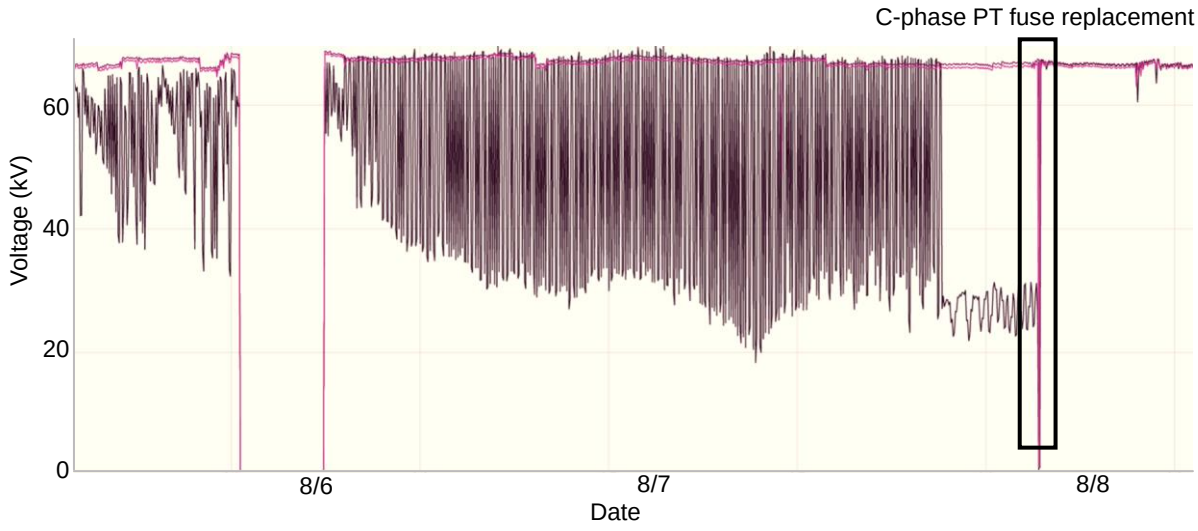
Second voltage transformer failure



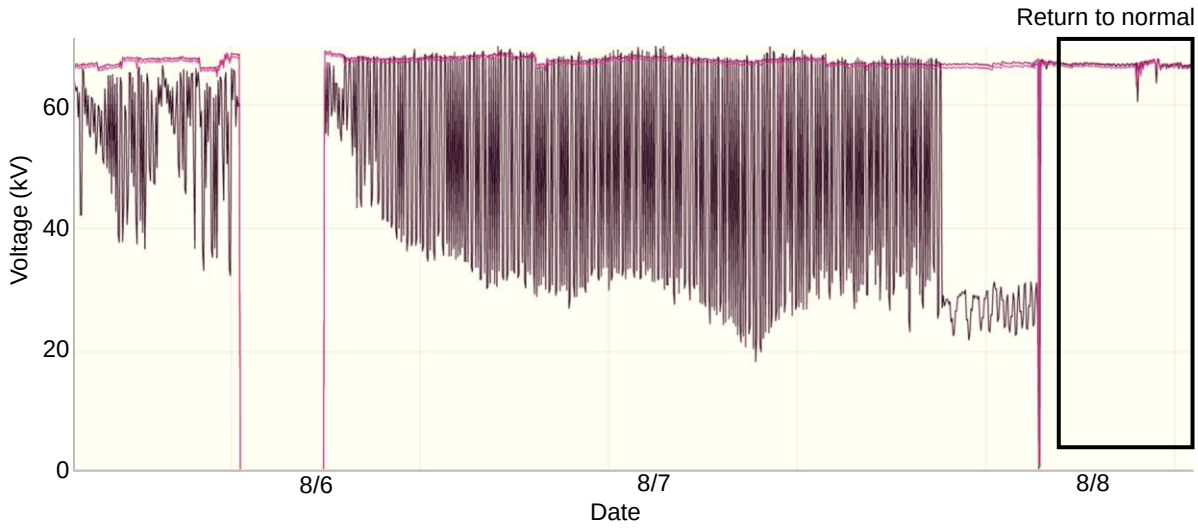
Second voltage transformer failure



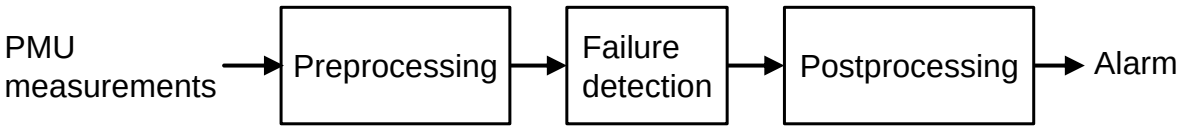
Second voltage transformer failure



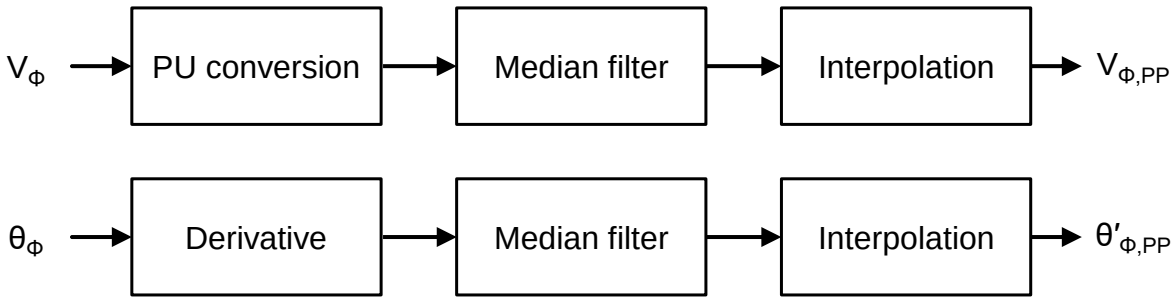
Second voltage transformer failure



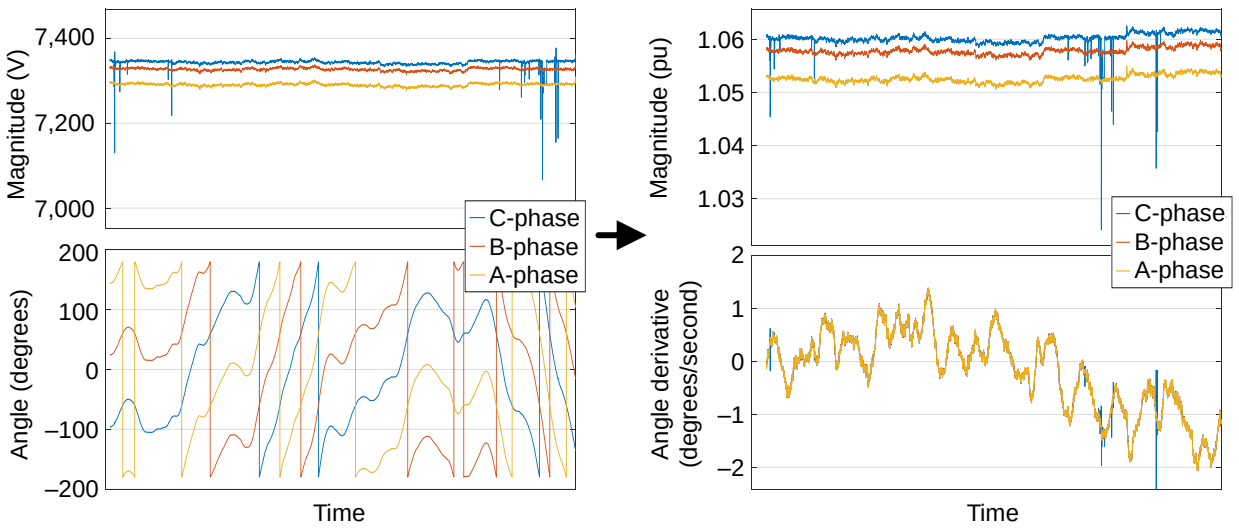
New synchrophasor-based detection method

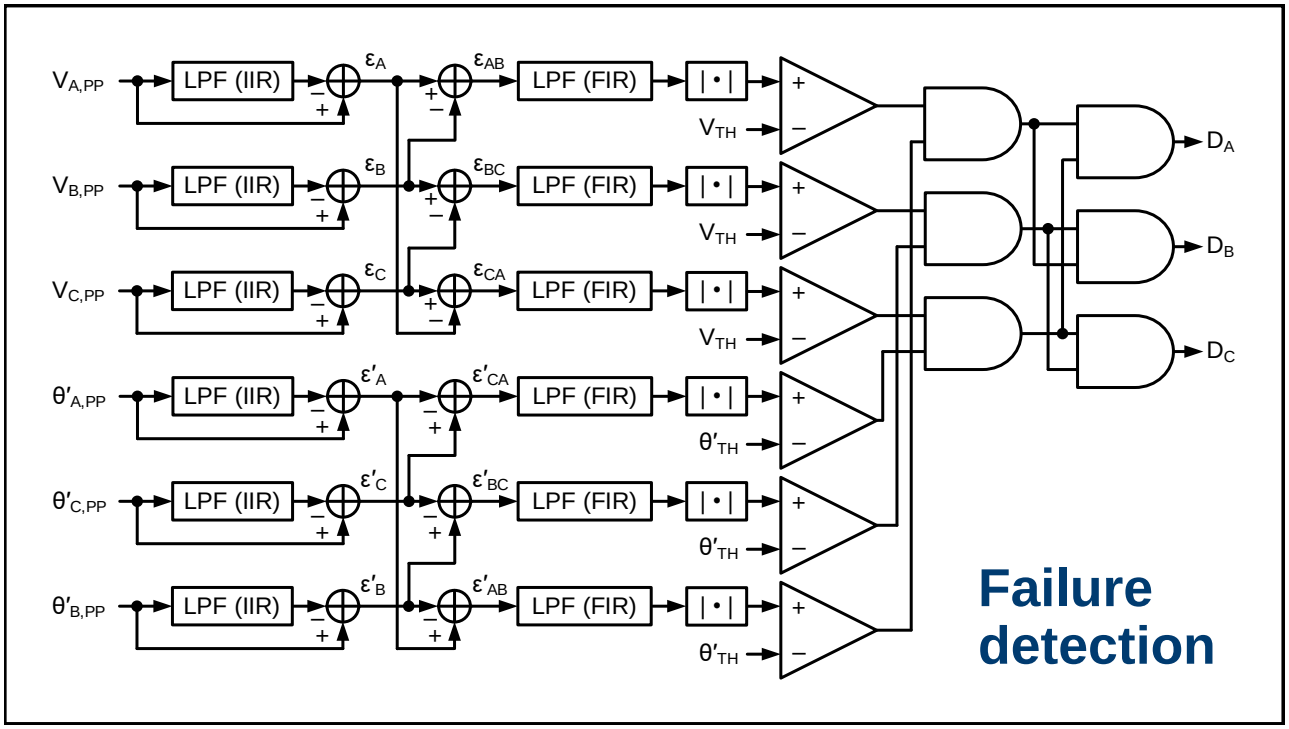


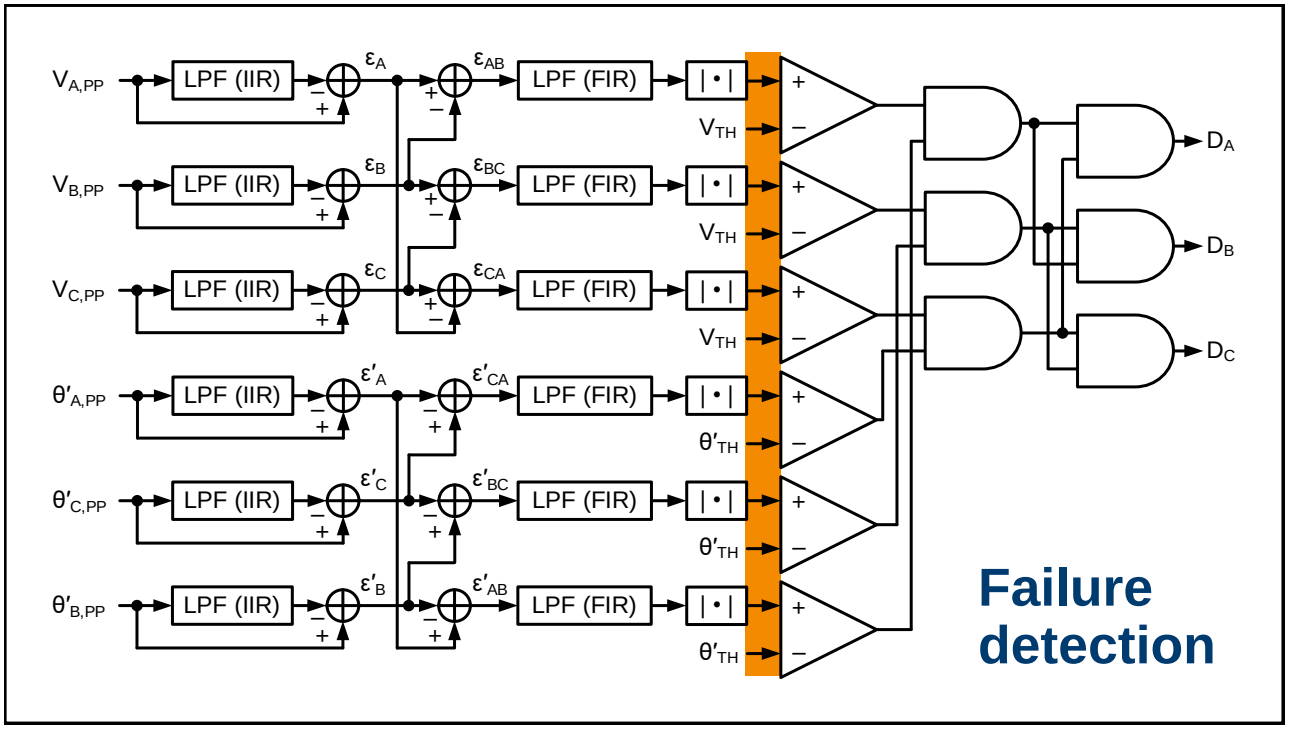
Preprocessing



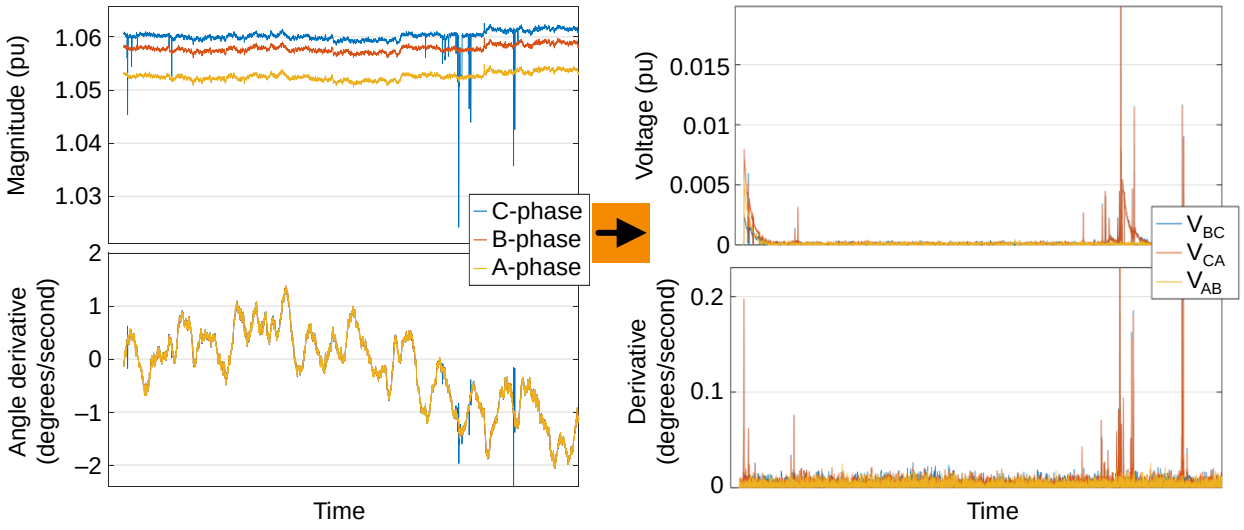
Preprocessing

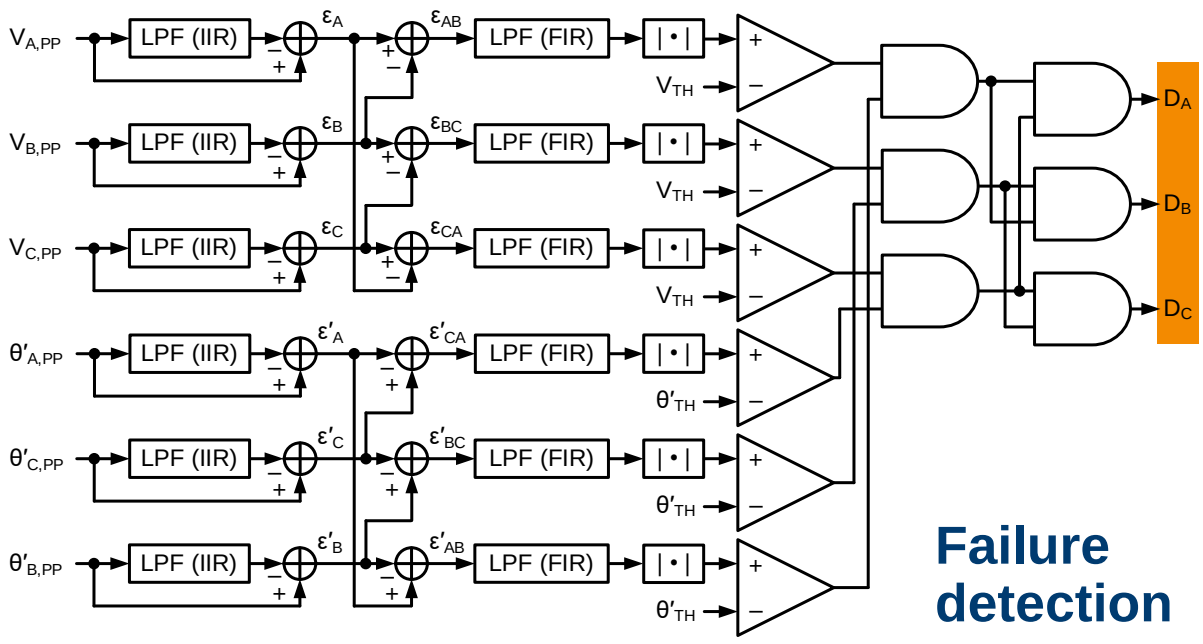



$V_{A,PP}$
$V_{B,PP}$
$V_{C,PP}$
$\theta'_{A,PP}$
$\theta'_{C,PP}$
$\theta'_{B,PP}$
LPF (IIR)
ε_A
ε_B
ε_C
ε'_A
ε'_C
ε'_B
ε_{AB}
ε_{BC}
ε_{CA}
ε'_{CA}
ε'_{BC}
ε'_{AB}
LPF (FIR)
| • |
V_{TH}
θ'_{TH}
D_A
D_B
D_C
Failure detection

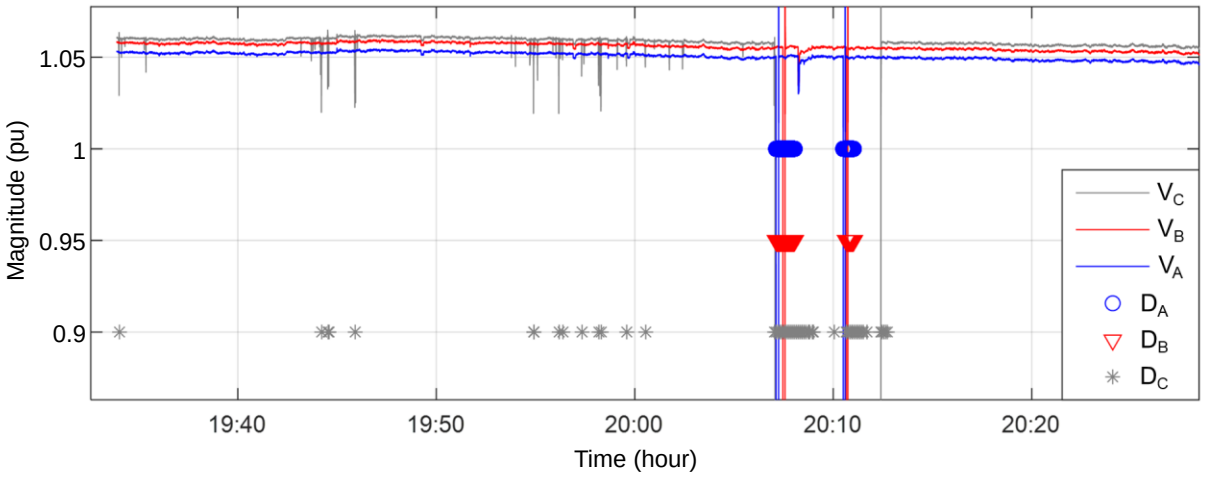

$V_{A,PP}$
$V_{B,PP}$
$V_{C,PP}$
$\theta'_{A,PP}$
$\theta'_{C,PP}$
$\theta'_{B,PP}$
LPF (IIR)
ε_A
ε_B
ε_C
ε'_A
ε'_C
ε'_B
ε_{AB}
ε_{BC}
ε_{CA}
ε'_{CA}
ε'_{BC}
ε'_{AB}
LPF (FIR)
| • |
V_{TH}
θ'_{TH}
D_A
D_B
D_C
Failure detection

Failure detection

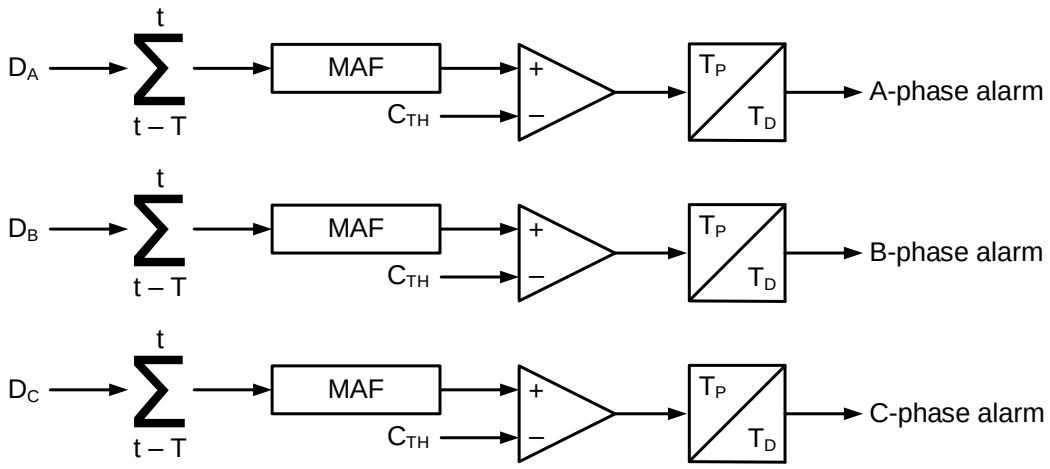




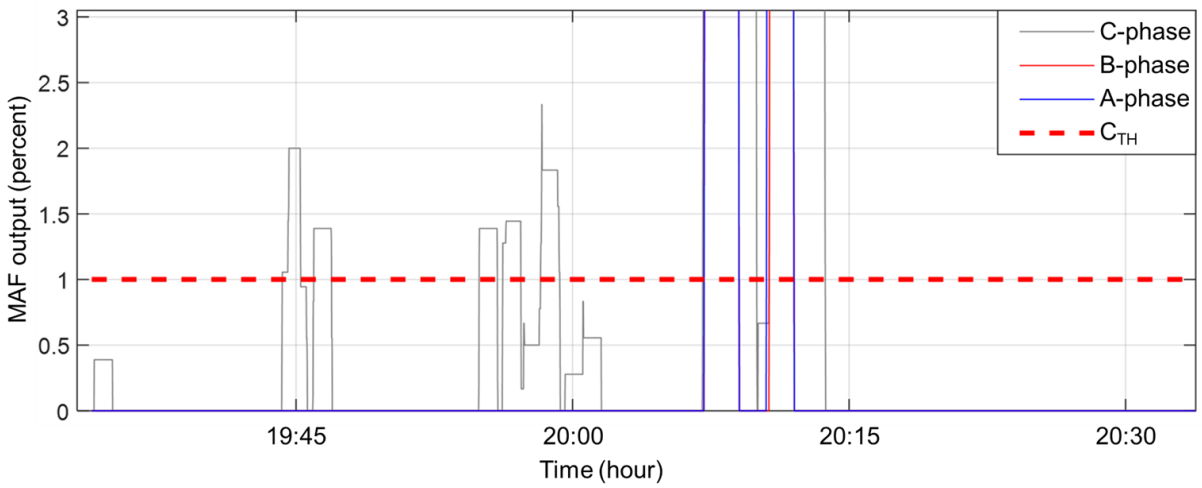
Failure detection

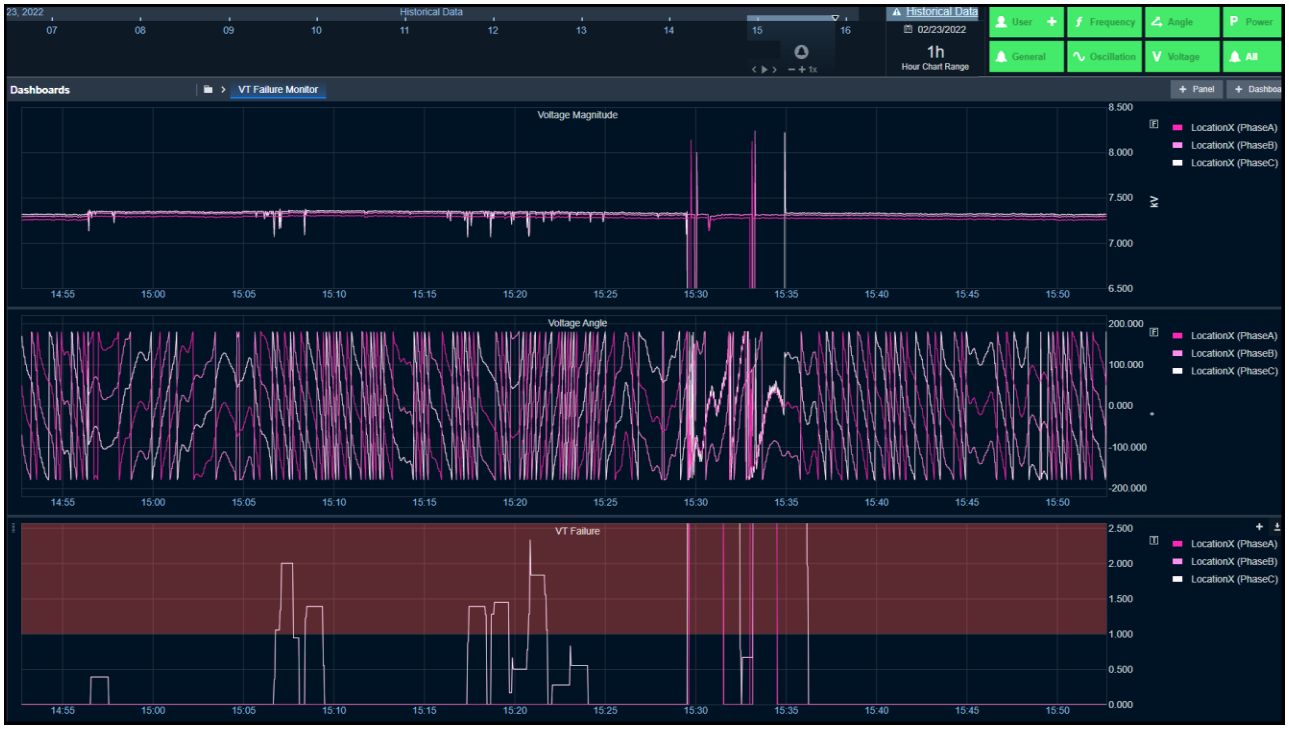


Postprocessing

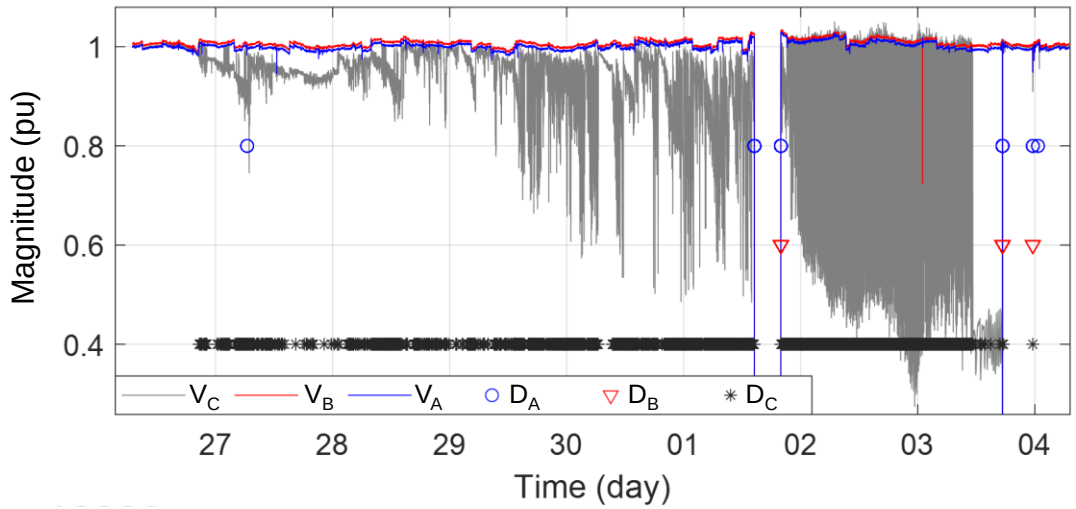


Postprocessing





Results for second voltage transformer failure




02/21/2022
10m
Minute Chart Range
Frequency
General
Oscillation
Voltage
All
Relay Targets
Three Phase Power
Panel
Dashboard
PhaseA Current Magnitude
EL.TL23051
678.457 A
GC.TL23051
676.748 A
PhaseB Current Magnitude
EL.TL23051
759.633 A
GC.TL23051
757.496 A
PhaseC Current Magnitude
EL.TL23051
701.101 A
GC.TL23051
699.392 A

Questions?