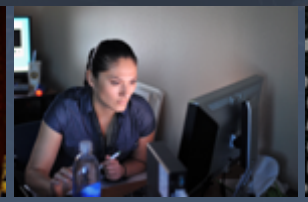
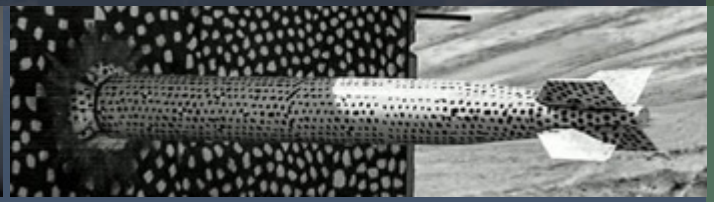
SAND2022-9548C

Sandia National Laboratories

Unintentional islanding detection via wide-area communication of reference signals





June 21, 2022

Michael Ropp, Ph.D., P.E.

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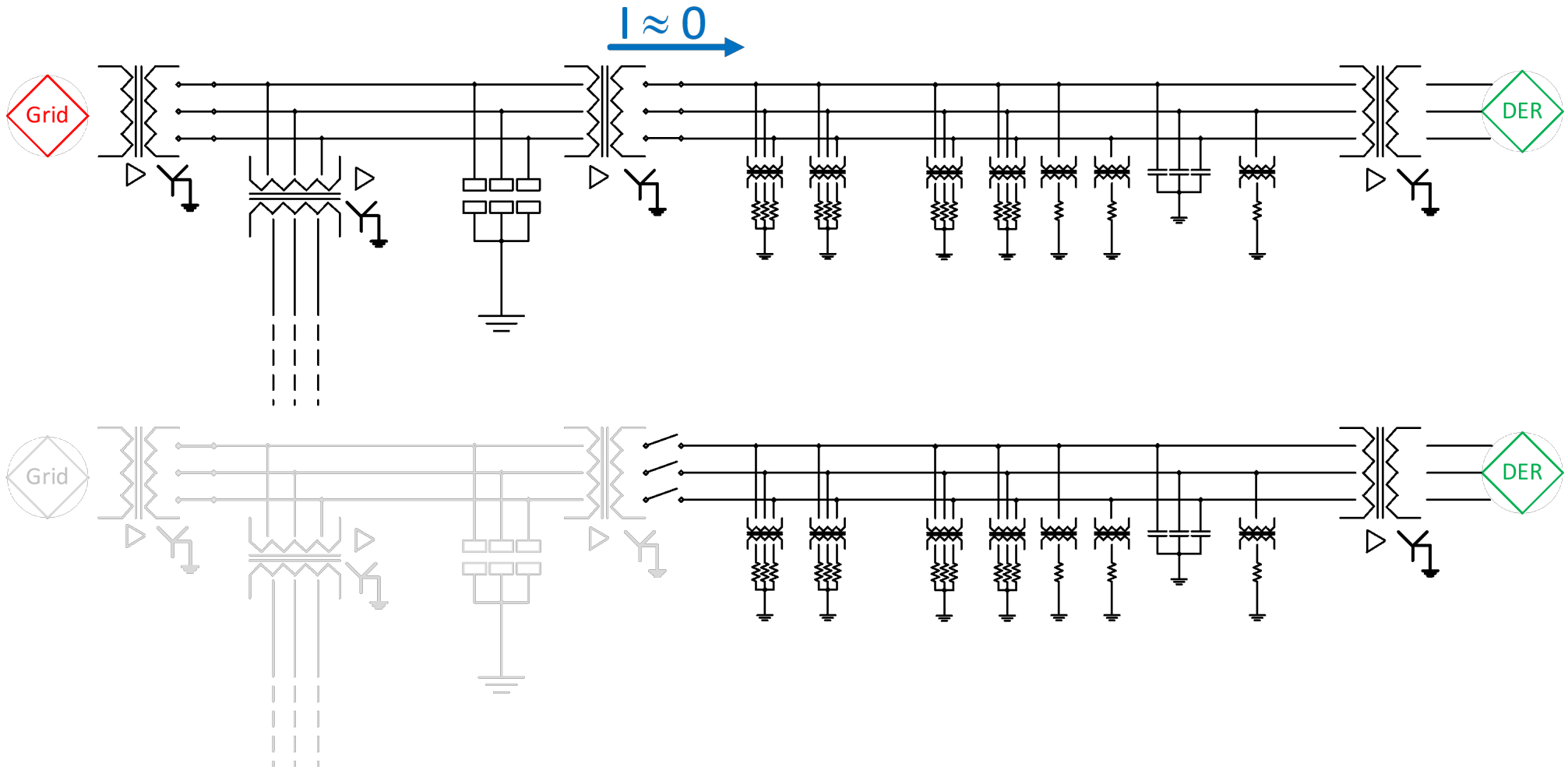
Unintentional islanding

$$P_{DER} = P_{load}$$

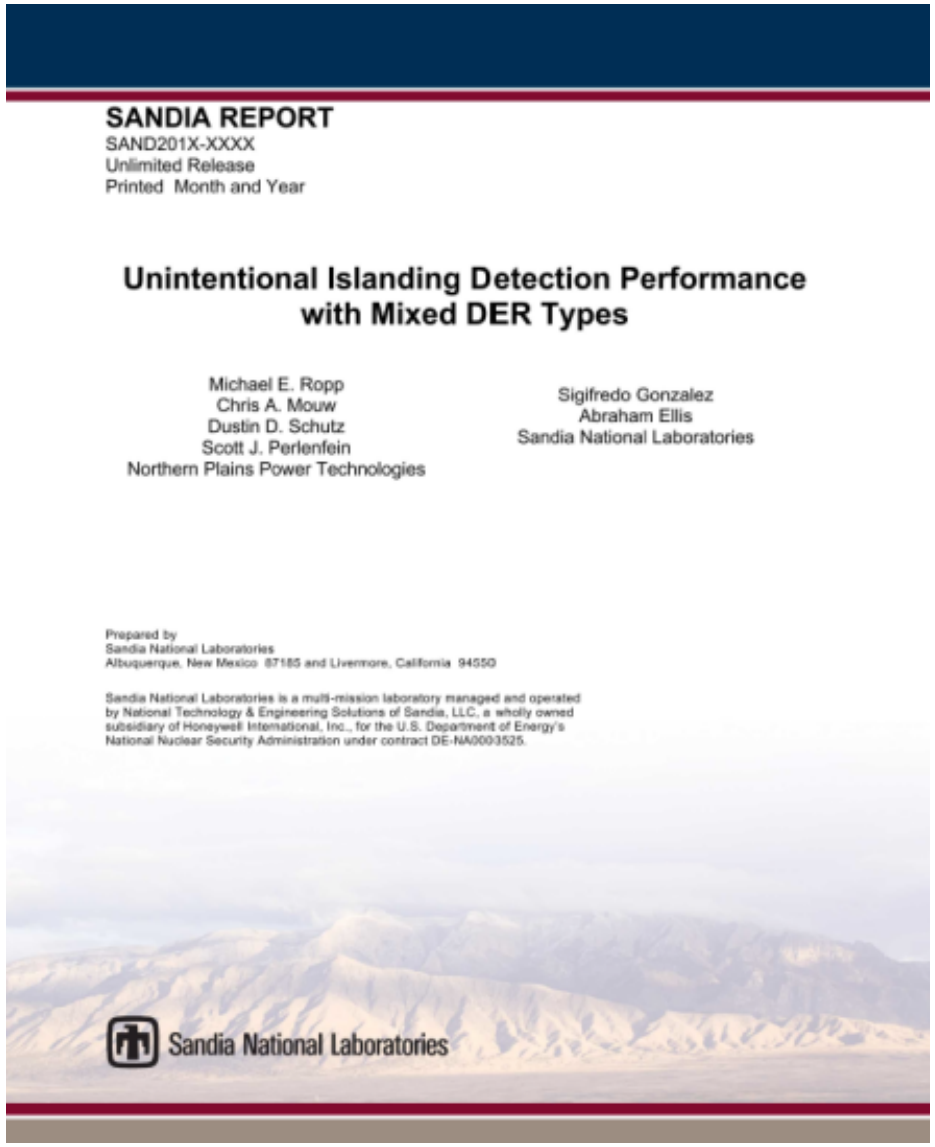
$$Q_{DER} + Q_C = Q_{load}$$

Self-excitation in which a DER continues to energize a portion of an electric power system (EPS) that has been fully isolated from the bulk EPS.



Unintentional islanding as a re-emerging concern

- Combinations of rotating and inverter-based DER
- Mixtures of different types of islanding detection method
- Impact of motor load
- Impact of ride-through requirements on run-on times
- Islanding detection in grid-forming inverters (??)



SANDIA REPORT
SAND201X-XXXX
Unlimited Release
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Unintentional Islanding Detection Performance with Mixed DER Types

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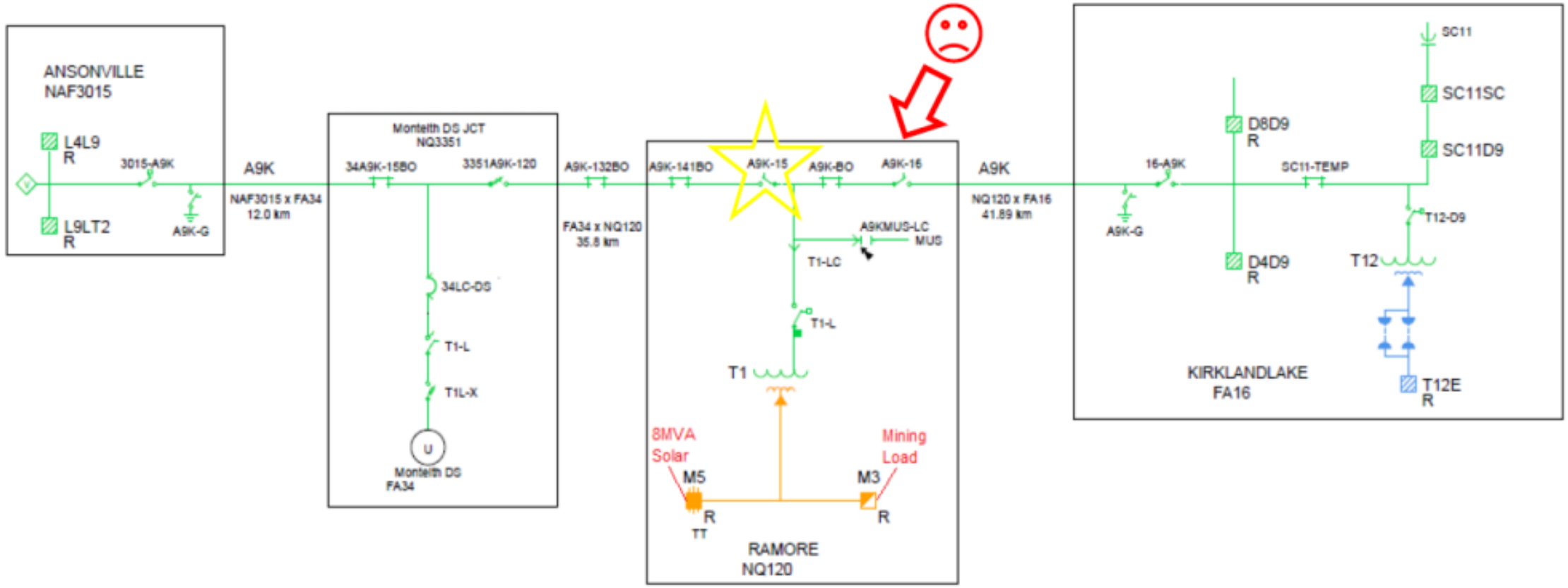
Has unintentional islanding ever actually happened in the field?

- Yes, but until recently, measurement-verified unintentional island events have been scarce.
  - One multi-inverter event
  - One event involving inverter-based and rotating DER
  - At least two events for utility-scale plants with extremely light loads
  - In none of these cases were sufficient measurements available for study, and none were ever replicated
- Recent event: Ramore, Ontario, Canada sustained island event
  - Well-documented
  - Motor load and transmission-line capacitance involved
  - What was the anti-islanding method in use?

Ramore sustained island event

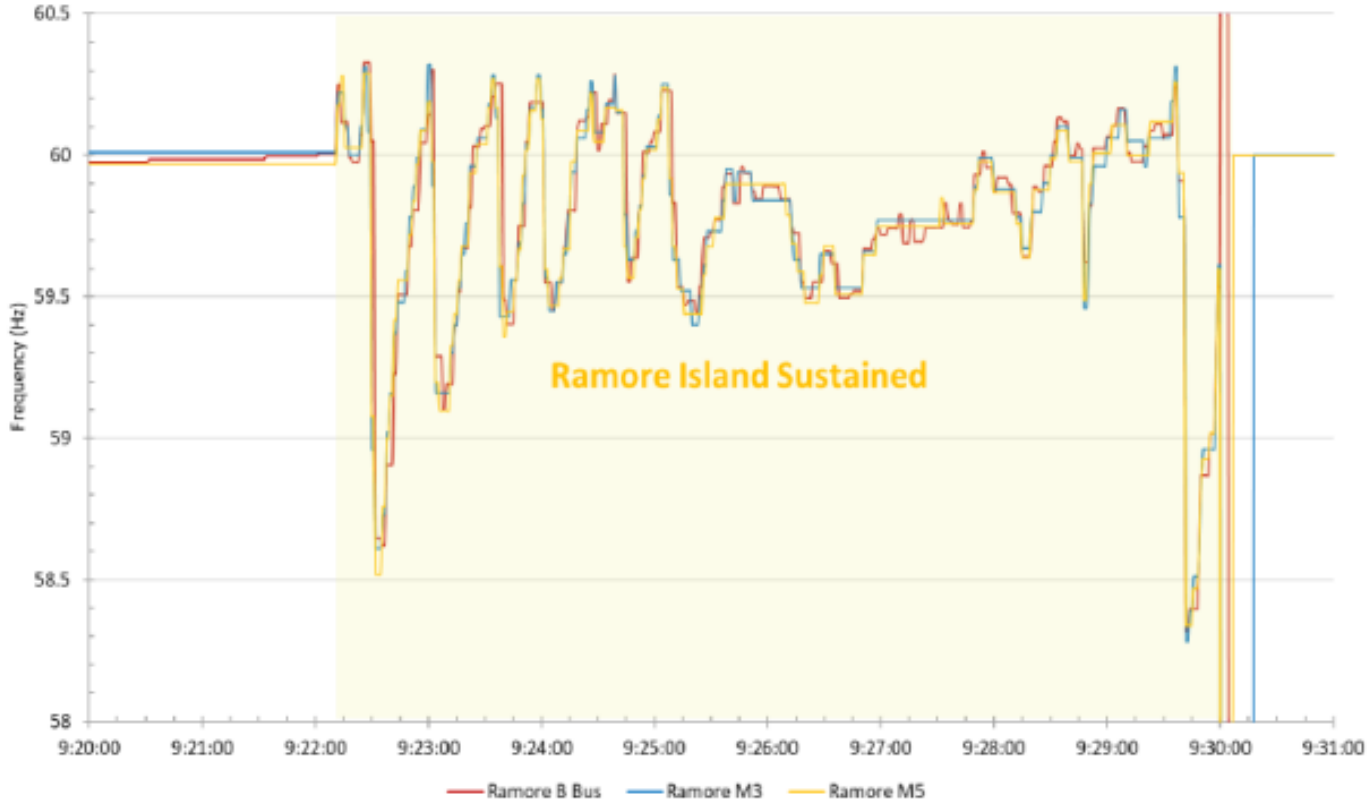
- Sept 12 outage intended from Ansonville TS to A9K-15
- At approximately 09:17, field staff inadvertently opened the A9K-16 switch when ordered to open A9K-15 at Ramore TS.



Provided by EPRI; from "DER Field Experience Interest Group Webcast #23", July 21, 2021.

Ramore sustained island event

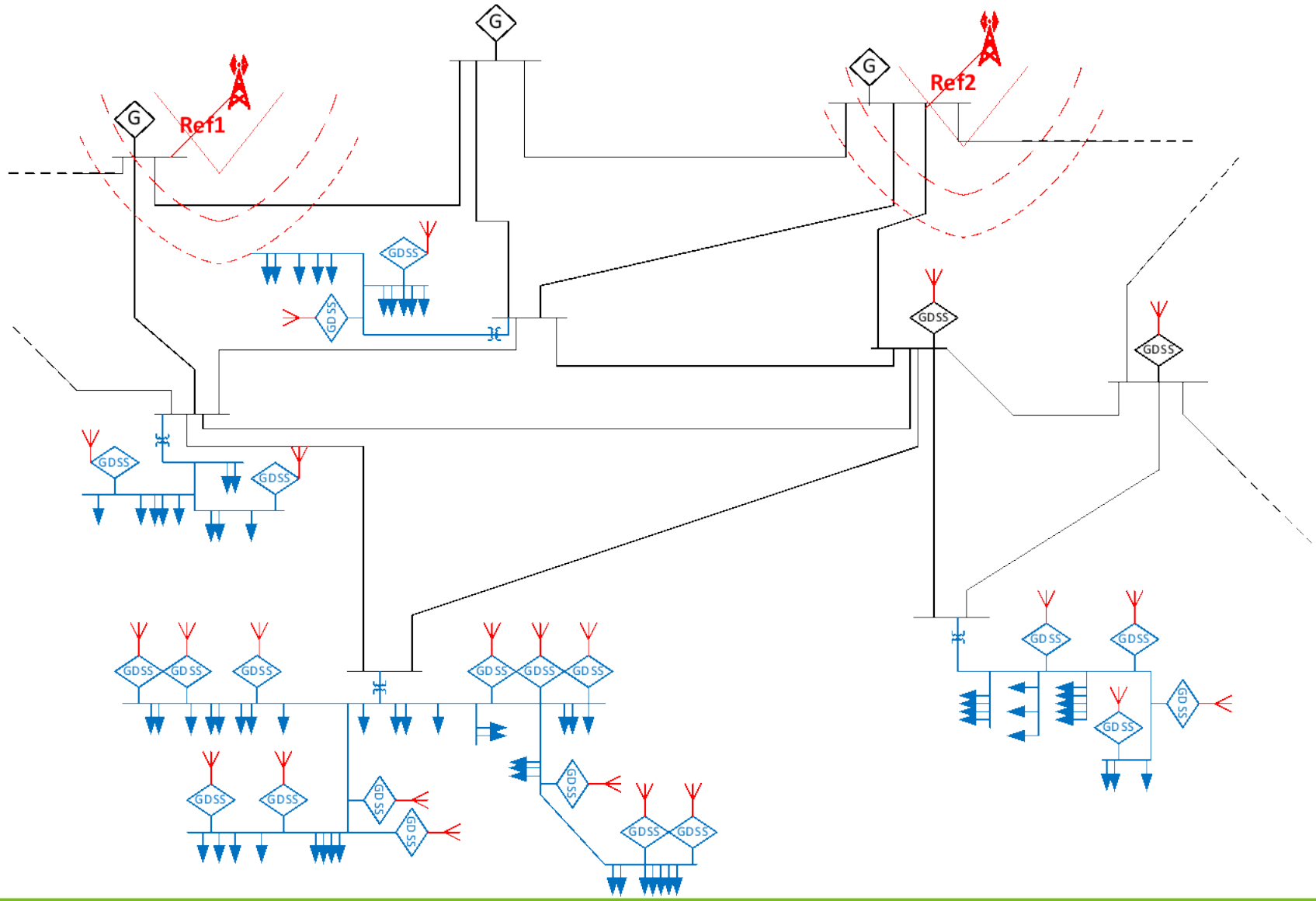
- During islanded condition, a sawtooth pattern was initially seen in the frequency, followed by a slightly varying pattern between 59.5 and 60.3Hz.
- Could oscillations be caused by active anti-islanding in inverters? Could the induction motor load on M3 prevent inverters from reaching trip thresholds?



Provided by EPRI; from "DER Field Experience Interest Group Webcast #23", July 21, 2021.

Wide-area signal-based islanding detection

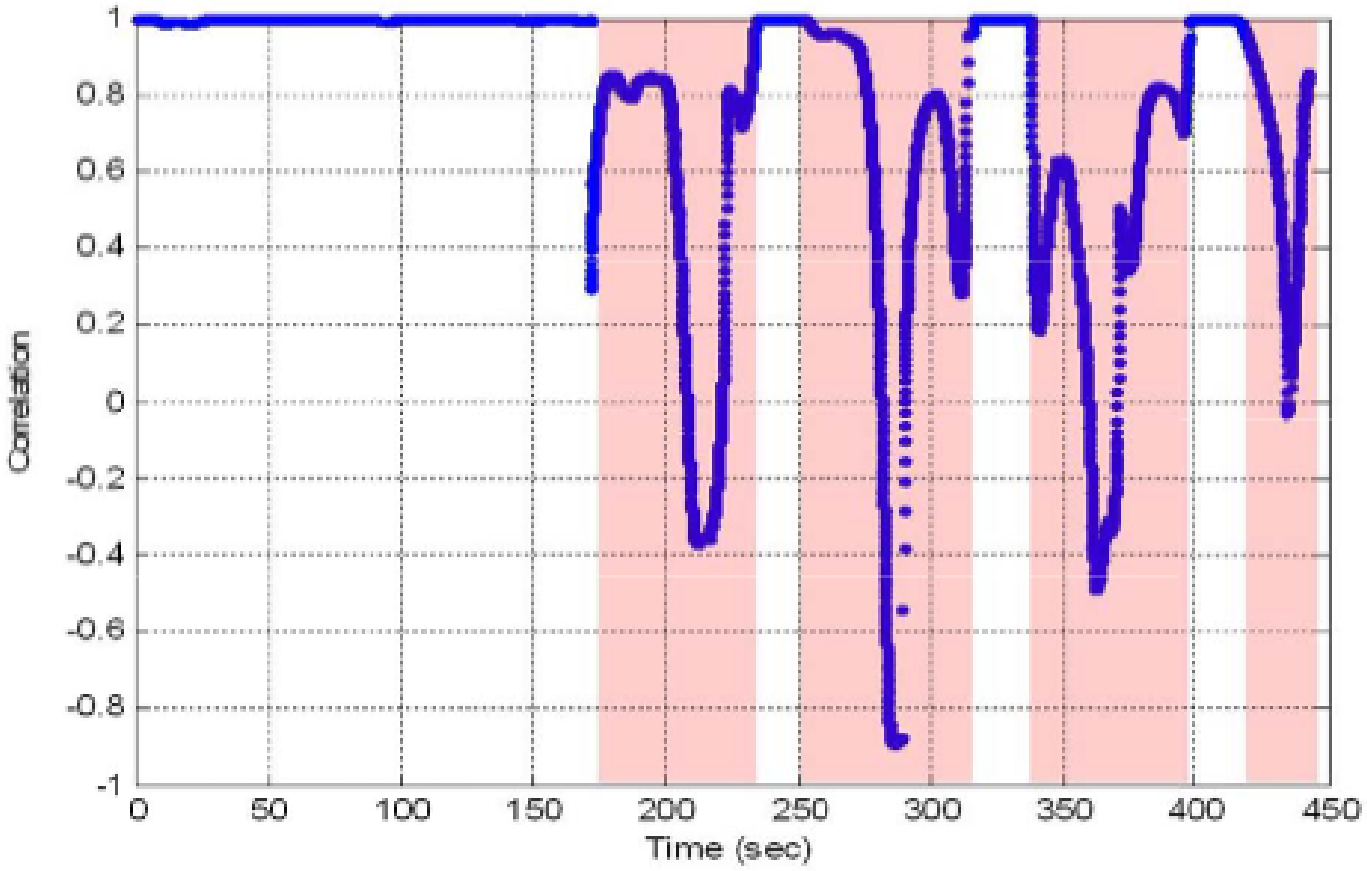
One concept for solving these challenges is to replace inverter-resident islanding detection with a wide-area islanding detection system based on broadcast reference signals.



Frequency references

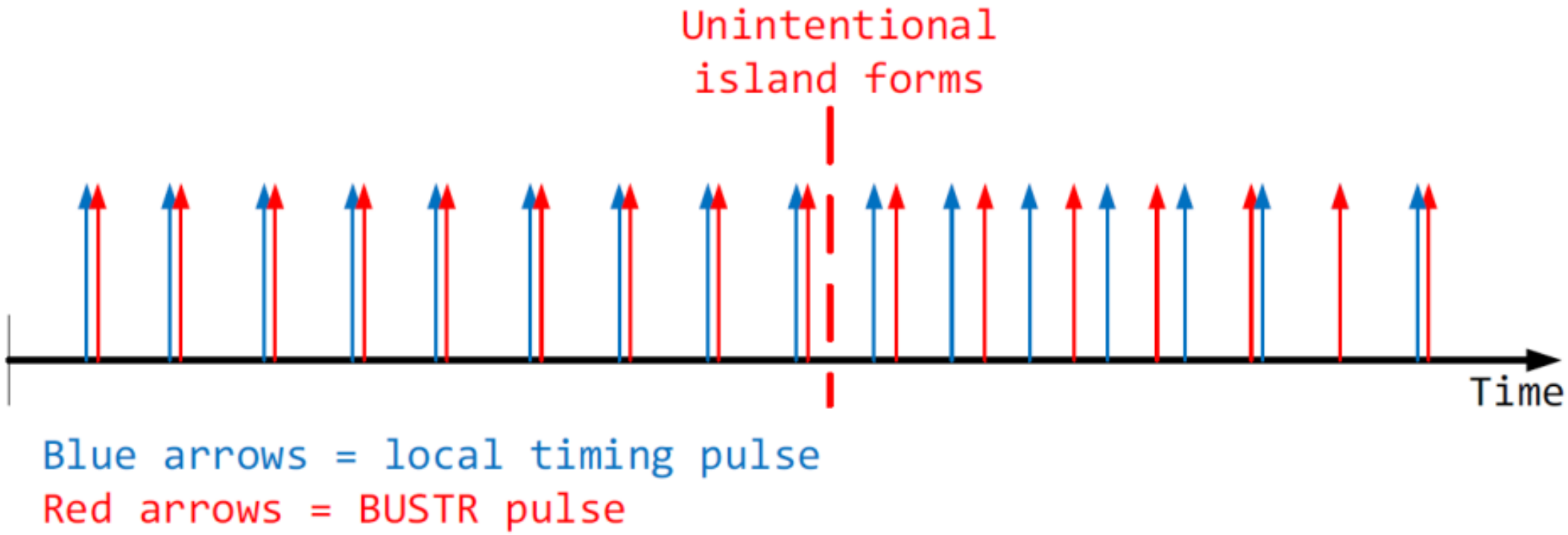
Frequency as the reference signal makes sense because frequency is more predictable **(not equal!!)** across large geographic areas. Combinations of parameters (e.g., ΔV with Δf with RoCoF) have also been proposed.

The use of broadcast time-synchronized phasor frequency for islanding detection has been demonstrated in theory, simulation, laboratory and field.



BUSTR

An alternative is a “heartbeat”-type BUlk System Timing Reference (BUSTR) signal. This concept seems feasible but is as yet unproven.



Benefits of a wide-area broadcast reference signal (non-exhaustive)

- The need for inverter-resident active unintentional islanding detection would be eliminated.
  - No high-penetration issues associated with destabilizing positive feedback
  - No potential for conflict between grid-forming or grid-support controls and islanding detection
  - No need for unintentional islanding detection certification tests on GDSS equipment
- Scalable, adaptive grid support services from DERs and IBRs could be supported. Examples:
  - identification and damping of system oscillations;
  - FIDVR mitigation via system-aware adaptive var support;
  - unlocking of the potential of grid-forming inverters to stabilize the grid, assist in system recovery, and intelligently form intentional islands.

The key issue: broadcast channel?

- Dedicated broadcast network? LORAN-type?
- AM band?
- 5G?

Considerations include cost, cybersecurity, and reliability.

A viable business model is crucial. (Maybe a Federal agency—LORAN model?)

Data rate is also a major issue—to ensure fast detection, more data are better.

References

- Sandia National Laboratories report SAND2018-8431, “Unintentional Islanding Detection Performance with Mixed DER Types”.
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Thank you!

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