Use Case

Downed Conductors Detection

Reducing Wildfire and Public Safety Risks

GRID20/20®
Maximize Grid Reliability

October 2020

UC_Downed_Conductor_v1 Rev. A.2

Executive Summary

Electric Distribution Grids are outfitted with protection equipment that detects short-circuit fault conditions and operates to protect the system. Nevertheless, in many cases where a conductor breaks and falls toward the earth, surface contact resistance causes the resulting fault to draw too little current to activate conventional protection equipment. This type of condition is known as a **high-impedance fault**.

Industrywide, it is generally understood that conventional protection equipment is unable to detect approximately 30 to 50% of high-impedance faults caused by downed conductors. This means that energized conductors can rest on or near the ground, undetected and in a live state for lengthy periods; threatening public safety, and potentially igniting wildfires without utility operator awareness.

A line with a high-impedance fault can remain energized while resting on or near the earth. In some situations, there is no visible indication that a downed conductor is energized, thereby increasing the possibility of causing serious injury or death. In other cases, an arcing downed conductor can ignite vegetation and other materials, especially if it occurs in an area of elevated fire risk.

A live, downed conductor starting a fire

It is common for a downed conductor to remain energized for several minutes or perhaps hours; until a customer calls the utility company to report a lights-out condition, someone reports the incident, and/or a resulting fire is observed. Even in cases where conventional protection components finally engage, the previous period of arcing may have already started a wildfire.

Unfortunately, these instances are no longer an uncommon occurrence within our aging grid infrastructure.

GRID20/20's Advanced Transformer Infrastructure (ATI) OptaNODE Sensor Solution will improve the rapid detection and locating of downed conductors. As expressed by an Investor Owned Utility Testimonial noted within this Use Case, secondary side intra-grid sensors are capable of detecting primary side downed conductors.

As a result, additional Fire Mitigation advancements are now being developed by GRID20/20 and tested by various grid operators.

For decades, the electric power industry has struggled to find an effective solution to swiftly identify downed conductor high-impedance fault events, which pose significant public safety challenges, and represent highly volatile fire ignition sources.

Associated liability concerns have magnified throughout the industry. In the wake of multiple devastating grid asset failure-induced wildfires, we have witnessed scores of human fatalities, untold environmental and wildlife damage, massive property and building destruction, millions or billions of dollars annually associated with fire suppression costs, the bankruptcy protection filing of the largest U.S. electricity provider, and billions of dollars in lawsuits and legal damages.

Clearly, this ongoing problem requires the development and adoption of a more reliable solution.

Downed Conductors

30~50% of occurrences — not detected by traditional protection equipment

GRID20/20 now offers an alternative approach for detecting high-impedance faults based on secondary Voltage monitoring; versus traditional, less-effective approaches that are based on primary Current measurements.

Advanced Transformer Infrastructure (ATI): OptaNODE™ Sensor Solution

- ✓ Enables the detection of high-impedance faults caused by Downed Conductors
- ✓ Reduces safety risks, such as electric shock and fire hazards

Proactively detecting and locating live, downed conductors will help to protect the public from safety hazards, and will reduce wildfire occurrences.

Challenges

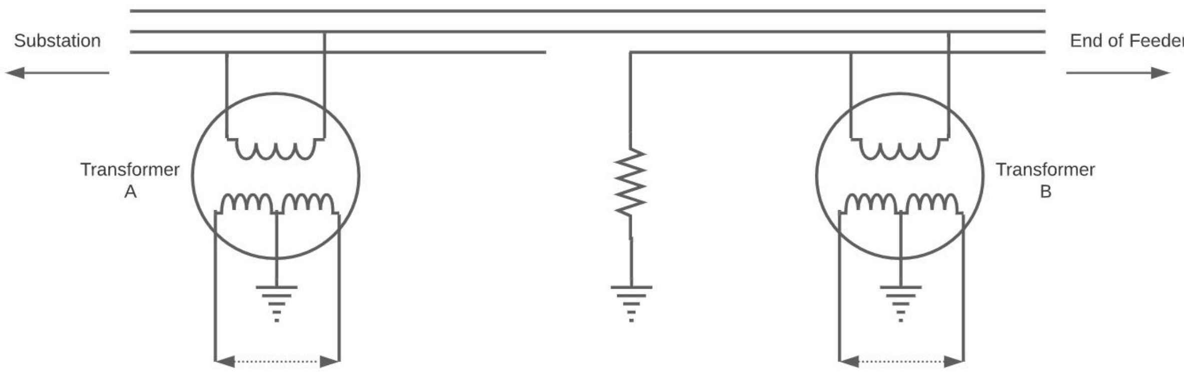
Live, downed conductors create high-impedance faults that may not be detected by standard protective devices, leaving the energized wire exposed. On most distribution circuits, if an energized conductor drops to the ground without contacting a neutral wire, the high-impedance fault will draw very low currents which oftentimes are not detectable using conventional overcurrent protection devices. **The characteristics of high-impedance faults, together with their random occurrences, increases the difficulty of their detection by conventional equipment.**

Despite decades of research, this ongoing condition has remained an unsolved, serious problem.

A downed conductor fault typically has a very low current value which is oftentimes not detectable by conventional overcurrent protection devices.

Additionally, conventional approaches lack selectivity. When a potential high-impedance fault is detected by a substation-based protection system, the entire feeder is de-energized. If the system inaccurately determines there is not a fault occurrence, when there actually is, the immediate reconnection of the faulted branch creates a risk of injury to people and damage to downstream equipment. On the other hand, if the system inaccurately determines there is a fault, then unnecessary downstream power outages ensue and field crews must be dispatched to verify the state of the lines before making the reconnection. This laborious step typically implies a protracted service interruption due to line crew travel time and troubleshooting.

For these reasons, it is very important to adopt efficient downed conductor identification techniques that will accelerate the operator's awareness and response time.



High-impedance fault on load line, creating a backfeed condition of reduced voltage

Limitations of conventional mechanisms can now be eliminated using a distributed detection system that monitors secondary Voltage levels, Voltage imbalance, and Outage detection.

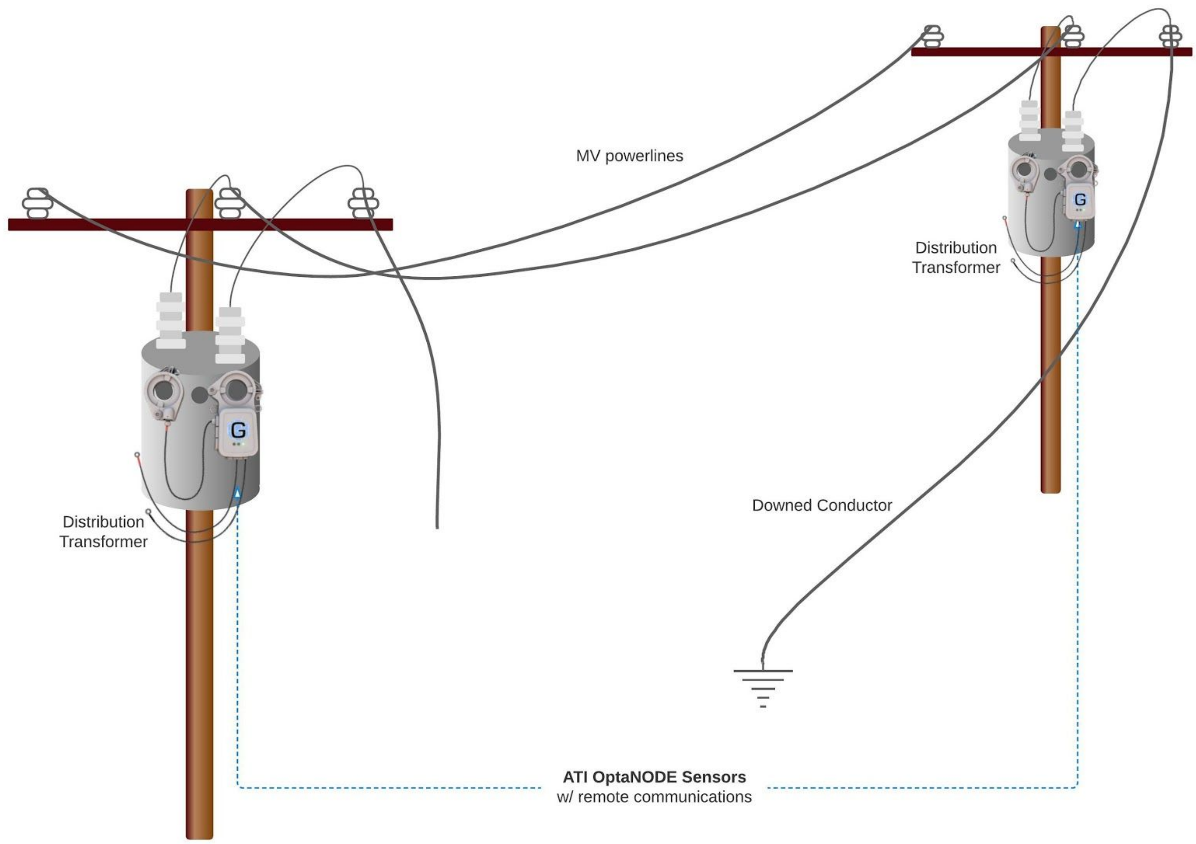
From public safety, wildfire mitigation, and operational reliability points of view, the swift detection and remediation of high-impedance faults is critically important.

Solution

Historically, there has been no highly-effective method for swiftly detecting downed conductors. Most utilities commonly rely upon incoming calls to report downed conductor occurrences. But, this antiquated approach certainly does not fully address the problem, as explained above.

GRID20/20's method for detecting high-impedance faults caused by downed conductors is based on precise, timely information obtained directly from the secondary side of Distribution Transformers. This unique approach allows utility operators to quickly (i) ***Detect*** high-impedance faults and distinguish outages caused by a broken or downed conductor — rather than a blown fuse; and (ii) ***Identify*** the fault location.

Detection reduces public safety and fire risks. Location identification enables faster utility response, and first responder intervention (if necessary). This results in faster service restorations and reduced operator liabilities; **all at lower costs and reduced impacts.**



ATI OptaNODE Sensors can report secondary Voltages impacted by MV Downed conductor events and issue Automated Alerts

ATI OptaNODE Sensors can be deployed at key locations along a feeder, or ideally on every Distribution Transformer to provide a quick detection and location-establishing solution. For utility operators already using GRID20/20's ATI OptaNODE Sensor Solution, Downed Conductors detection can now be added to the existing list of multiple value propositions presented by Advanced Transformer Infrastructure (ATI), (e.g., Volt/VAR Optimization, PV Management, Asset Monitoring, Outage Notification, etc.).

ATI OptaNODE Sensors will play a major role in the effective identification of live, downed conductor events that might pose public safety hazards or ignite wildfires.

Detection

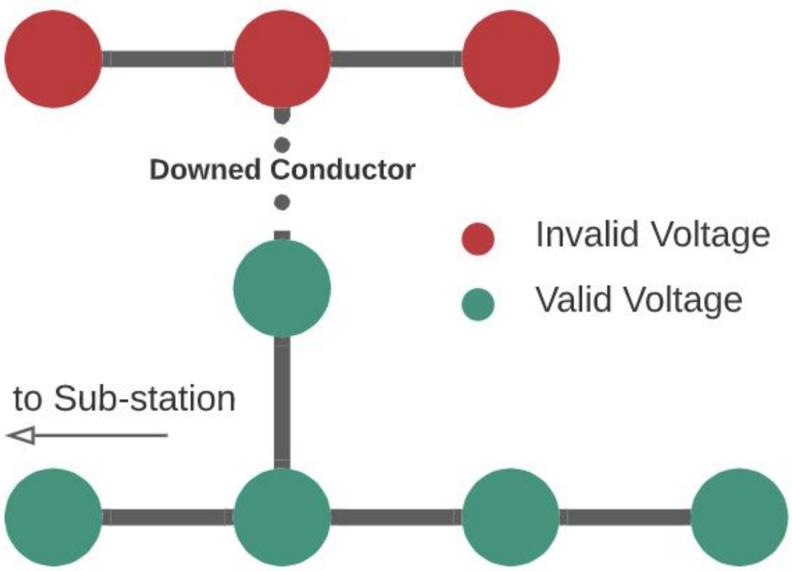
Different high-impedance fault events can create different secondary side conditions, depending on the scenario. By utilizing timely secondary side information (e.g., Voltage levels for each phase, Voltage Imbalance data, Outage status, etc.) from each Distribution Transformer equipped with the ATI OptaNODE Sensor Solution, high-impedance fault conditions can now be promptly detected and reported.

The use of this proactive detection method will accelerate utility and/or first responder awareness.

- ✓ Accurate, Timely Voltage Readings
- ✓ Critical Voltage-Level Alert Notifications
- ✓ Power Outage *and* Restoration Notifications

Location Identification

Using accurate information reported by the Advanced Transformer Infrastructure (ATI) OptaNODE Sensor Solution, combined with topology information, Distribution Transformers located above and below the fault can be rapidly identified. This unique intra-grid sensor capability empirically narrows the search scope concerning fault location, given sufficient deployment of the solution.



Identification of Nodes upstream and downstream from the fault

GRID20/20 offers a flexible Application Programming Interface (**API**) for simplified field data extraction. The integration of ATI data with data from multiple sources, such as existing Utility systems (e.g., GIS, ONS, etc.), can expedite location identification. Depending on the scenario and data availability, the fault's location can be accurately pinpointed, or the search scope can be narrowed, either way reducing the time spent by crews in the field locating the downed conductor.

By providing timely, pinpointed location data directly from the field, the ATI OptaNODE Sensor Solution can enable operators and First Responders to accelerate their responses.

The ATI OptaNODE Sensor Solution can enable the reliable detection of downed conductors, and constitutes the starting point for additional advanced fire mitigation techniques.

Field Results

This novel approach to downed conductor detection was validated recently by Hawaiian Electric, a U.S. Investor-Owned Utility. The occurrence of a primary downed conductor event, that subsequently ignited a fire, was recorded by the GRID20/20 ATI OptaNODE Sensor Solution.

Utility Testimonial

"In June 2020, a brush fire occurred under a Hawaiian Electric 11.5-kV primary distribution line. An investigation found that the C-phase primary overhead conductor broke and fell between two poles. The downed conductor ignited the fire.

Further investigation revealed a GRID20/20 transformer monitor installed on the secondary of a 3-phase, pole mount transformer bank downstream of the failed overhead conductor span started recording abnormal secondary voltages several hours before the Honolulu Fire Department reported a brush fire in that area. A review of the GRID20/20 data found that recorded secondary voltage readings correlated with an open C-phase primary condition and a possible downed C-phase primary conductor.

This finding has led to discussions with GRID20/20 to develop enhanced features to its transformer monitoring system."

Actual field data recorded during the downed conductor event

OptaNODE HESS Secondary Voltage Graph

Key observations based upon the incident graph:

1. All voltages were normal until 03:15 local time.
2. At 03:30, the A-phase voltage remains normal but the B- & C-phase voltages go abnormally low and never return to normal.
3. An open phase condition on the 11.5 kV side of this transformer bank caused the recorded secondary voltages, which correlate with abnormal secondary voltages expected for the open C-phase condition: the secondary A-phase voltage remains normal but the B- and C-phase voltages decrease to a range between 0.3 to 0.7 per unit of normal voltage.
4. The B- and C-phase voltage fluctuations after 10:00 may have been caused by the open C-phase condition in combination with the other primary conductors being involved in the fire.
5. Power was interrupted at 14:00 to perform the necessary repairs.
6. Service was restored around 21:00, and all voltages returned to normal.

Conclusions

Based on the lessons learned from this event, GRID20/20 has continued to work in close cooperation with this IOU. The new **Critical Alerts** capability recently implemented by GRID20/20 will notify Utility operators about future incidents in near real-time.

The combination of ATI OptaNODE Sensor data with GIS and other Utility system data will allow for the improved determination and location of high-impedance faults. **These developments will help to minimize downed conductor impacts and outage durations; thereby collectively serving to reduce wildfire risks, decrease economic and environmental damages, lessen public safety risks, and reduce liability risks for operators.**

A Special Note on FIRE Prevention & Detection

The prevention and/or early detection of grid asset failures and wildfires represents a revolutionary advancement that is enabled by the ***ATI OptaNODE Sensor Solution.***

GRID20/20 continues to develop additional features designed to directly address the vital Fire Mitigation interests of utility providers and First Responders.

To learn more about what GRID20/20 is doing to address wildfire prevention and early detection, please contact us.

About Hawaiian Electric

For 129 years, Hawaiian Electric has provided the energy that has fueled the islands' development from a Hawaiian kingdom to a modern state. Hawaiian Electric serves 95 percent of the state's 1.4 million residents on the islands of Oʻahu, Maui, Hawaiʻi Island, Lānaʻi and Molokaʻi.

About GRID20/20 Inc.

GRID20/20 is a leading Distribution Transformer Monitoring provider possessing patented intra-grid sensors that reveal unique, accurate, granular, timely information from within electricity distribution grids. The versatility of GRID20/20's solution creates a myriad of operational gains for utility operators, and now first responders. The growing list of value propositions yielded by GRID20/20 includes improved DER integration, Greenhouse Gas Reduction, Outage Reduction, Improved Reliability, Accelerated Outage Restoration, Loss Identification, enhanced Energy Purchase Cost Reduction opportunity, Asset Loading information, increased Metered Revenues, Downed Conductor Detection, and Fire Mitigation capability.

GRID20/20 presents a globally relevant solution to address persistent distribution grid management and fire mitigation challenges.

For more information visit www.grid2020.com.

References

L. Garcia-Santander, P. Bastard, M. Petit, I. Gal, E. Lopez and H. Opazo, "**Down-conductor fault detection and location via a voltage based method for radial distribution networks**" in IEE Proceedings - Generation, Transmission and Distribution, vol. 152, no. 2, pp. 180-184, 4 March 2005, doi: 10.1049/ip-gtd:20041300.

Bjerkan, Eilert & Høidalen, Hans & Hernes, Johan, "**Reliable detection of downed and broken conductors**", 2007. https://www.researchgate.net/publication/229011476_Reliable_detection_of_downed_and_broken_conductors

Texas A&M, "**Texas Wildfire Mitigation Project**". https://wildfiremitigation.tees.tamus.edu/

EPRI, "**Finding Live Downed Conductors with AMI**". https://www.epri.com/research/products/3002012948

Photographs source: ***Texas Wildfire Mitigation Project***