PECAN STREET

Product Performance Testing Results: Anomaly Detection

March 2020

Athena Power UFD 1000

Product Description

Athena Power's UFD 1000 Fault Current Indicator (FCI) is a self-powered, wireless, and submersible sensor for underground distribution circuits. The UFD 1000 can be connected to electrical gear, such as transformers, reclosers, or pad-mounted switchgears, vaults or manholes. Per Athena Power, the UFD 1000 could find faults more quickly by providing real-time information directly to the utility's SCADA systems. Due to the wireless capabilities of the UFD 1000 device, Athena Power believes that their product can capture predictive data for future failures in underground circuits.

Product Application

When faults occur in the distribution system – whether because of faulty equipment, environmental, or other reasons – they should be immediately isolated to prevent hazards to the general public or utility personnel. Unfortunately, in underground lines, detecting a fault is difficult since visually inspecting a feeder is not possible. Although there are means of detecting ground faults underground, they are not efficient in determining the faulted element or location along the distribution feeder. As a result, utility personnel are required to manually disconnect every feeder in a substation to troubleshoot and find the fault.

For underground circuits, it is important that devices such as Fault Current Indicators (FCIs) are readily available for utilities to use and install. Having FCI sensors can help utilities find underground faults rapidly and efficiently without increasing the number and length of outages. Some of the largest manufacturers of fault sensors and grid protection devices are Siemens, Schweitzer Energy Laboratories, GE, and others.

FCIs are constantly measuring current on a circuit to know when a fault occurs. Therefore, some of these sensors can also be used as data loggers that are monitoring current at real time and reduce issues related to power congestion. These sensors, connected to the SCADA systems via WI-FI or fiber glass, can be extremely useful in the industry as the penetration of DERs on the grid increases.

Testing Setup and Overview

Since the UFD 1000 is a device that connects to distribution transformers, Pecan Street had to replicate large currents to resemble currents seen in distribution transformers. In order to do so, a Chroma programmable load was used to set up the current limits, and then the current wires were wrapped around the CT coils 40 times. The test setup is shown in Figure 1.

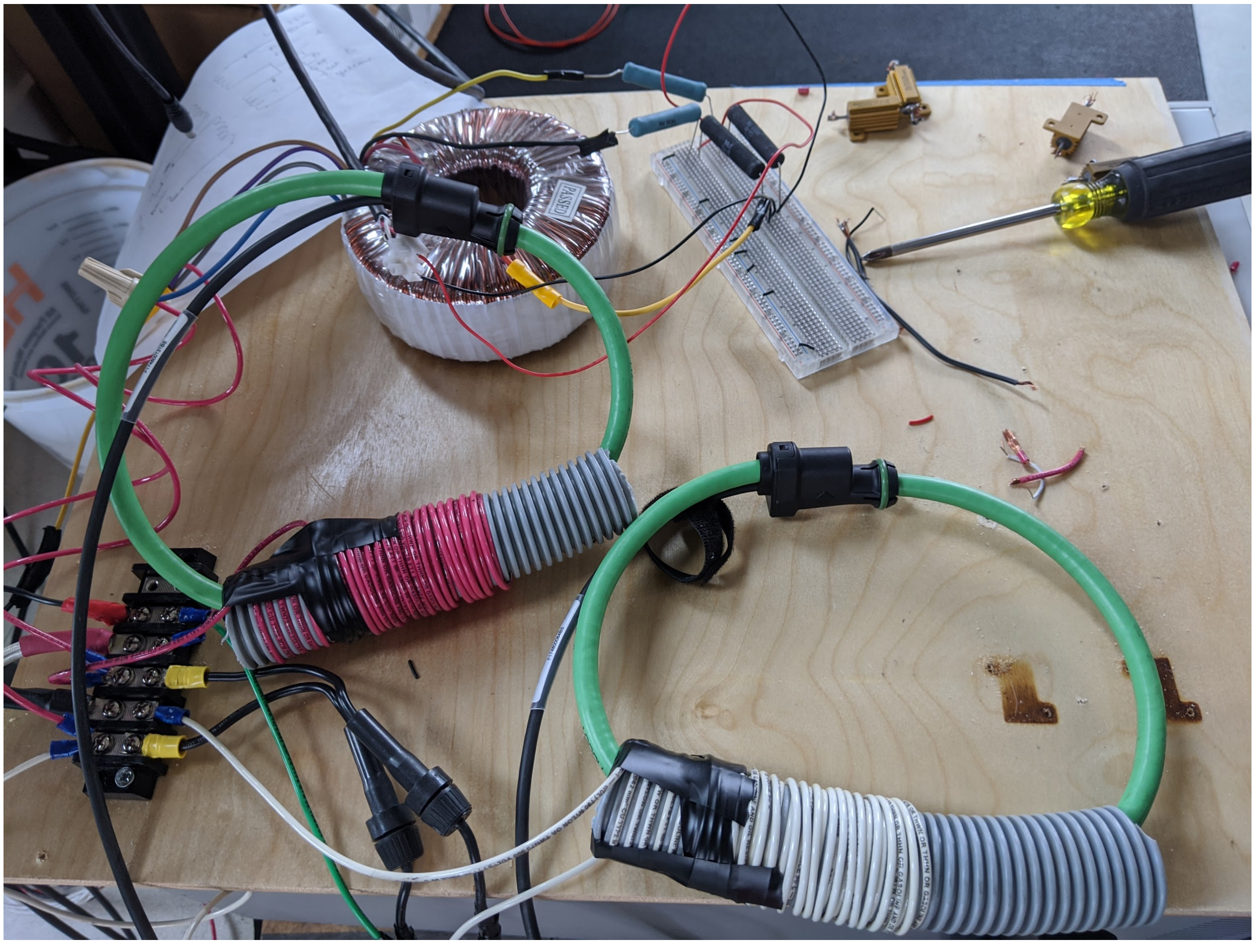

Figure 1 Test setup for UFD 1000

Analysis and Results

A six current UFD 1000 device was used for the Anomaly Detection test. The test was done to determine if the UFD 1000 device could be used as a technology that could aid utilities in determining whether load profiles were affected by vandalism or cyber-attacks.

Anomaly Detection

Athena power requested that Pecan Street do an application test for anomaly detection. To do so, Pecan Street ran the Chroma load through a determined load profile that would simulate streetlights. This load profile was provided by Athena Power.

A normal load profile for streetlights was one where the load is high during dusk and dark hours of the day and low during the daytime. This will vary depending on different times of the year; in the winter, the days are shorter, so the load is high for longer periods of time. Figure 2 is representative of a normal load profile for a winter day, where current is drawn by the streetlights until 9:00am and then there is no current drawn until 4:00pm – when the lights turn back on.

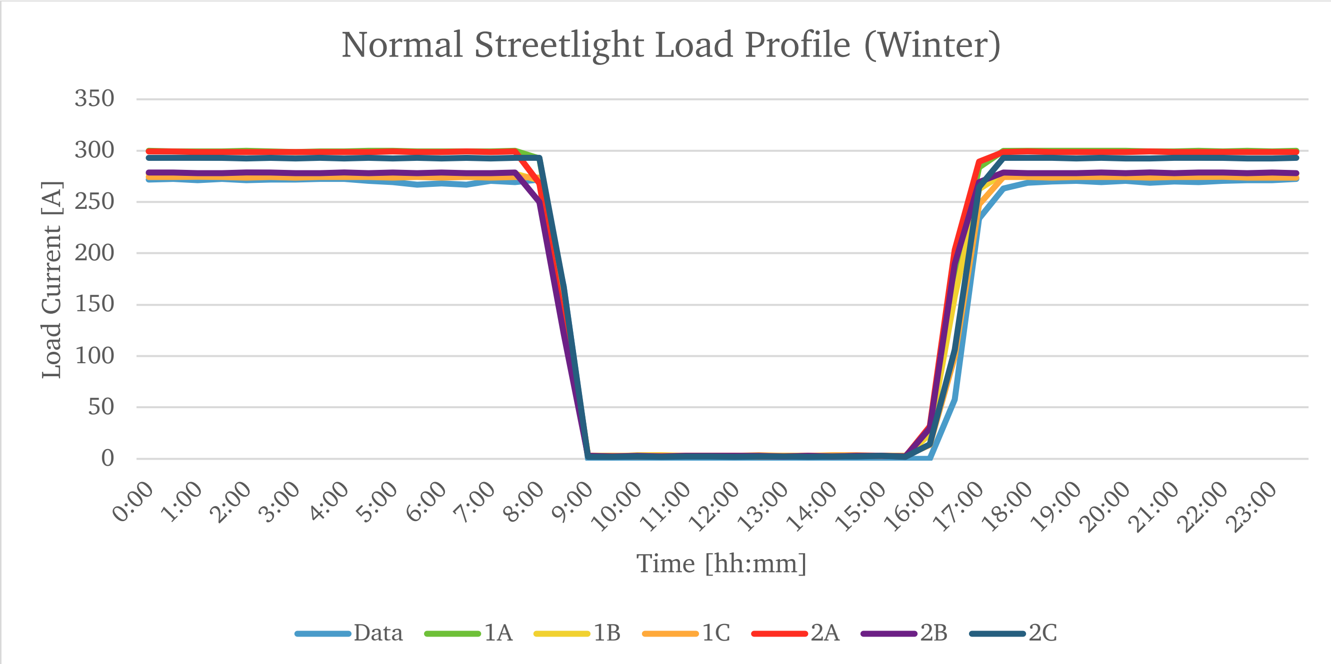

Figure 2 Streetlight load profile during the Winter. "Data" plots the load profile provided by Athena Power, while the Rogowski coils are represented by "1A", "1B", etc.

In Figure 2, each Rogowski coil (1A, 1B, etc.) on the UFD 1000 measured the current from the streetlight load profile very closely. This agrees with the current variability test summarized in the previous section.

For an abnormal day, the portion of the day when the load should be completely off, shows power being drawn. This could be due to vandalism happening on the line – people stealing power – or it can also be an indication of cyber-attacks. Figure 3 shows the load profile for an abnormal day. Again, for an abnormal day, the UFD 1000 measures the current from the load very closely.

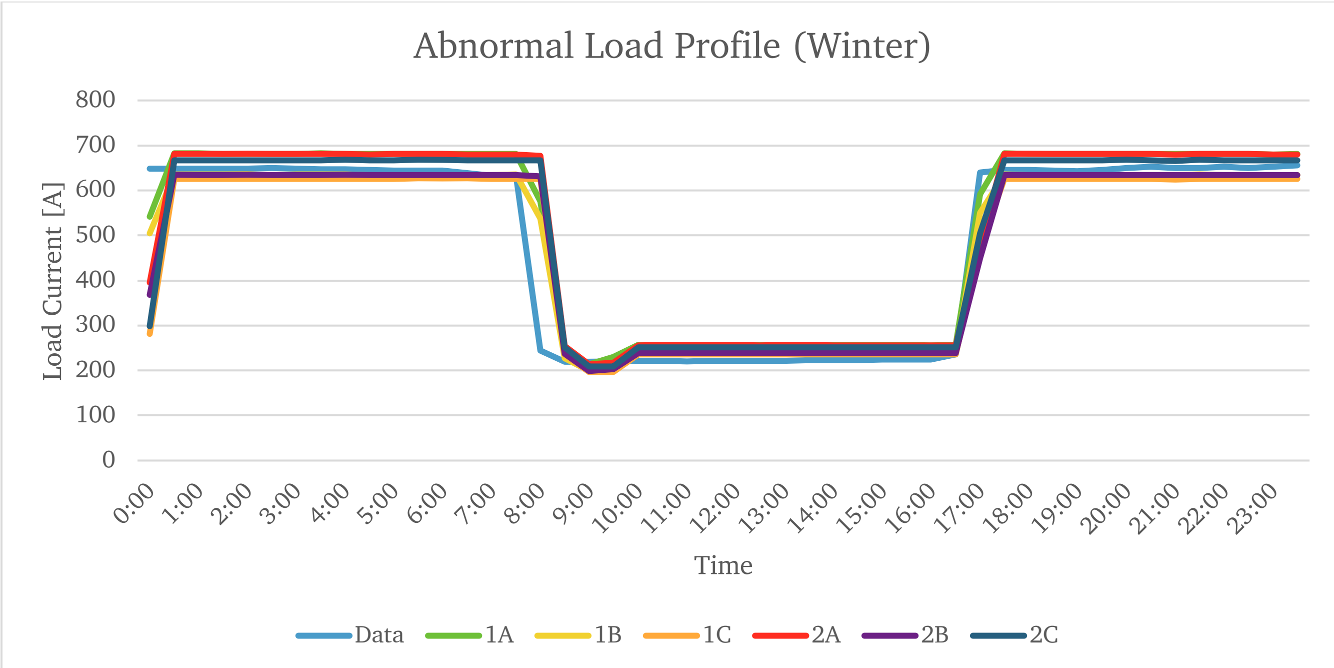

Figure 3 Abnormal streetlight load profile during the Winter. "Data" plots the load profile provided by Athena Power, while the Rogowski coils are represented by "1A", "1B", etc.

In the GUI of the UFD 1000, the user sets the correct load profile for a streetlight load in the winter (Figure 2). If the UFD 1000 then measures an abnormal day (like the one shown in Figure 3), it can flag an abnormality in the profile. The Pearson correlation is above 0.9 during the time the device follows the load, showing a normal correlation between measurement and uploaded profile. However, as soon as the load continues to draw current (when the UFD 1000 sees there should not be load), the Pearson correlation is around 0.2, representing an abnormality. The difference in normal vs. abnormal load is represented in Figure 4.

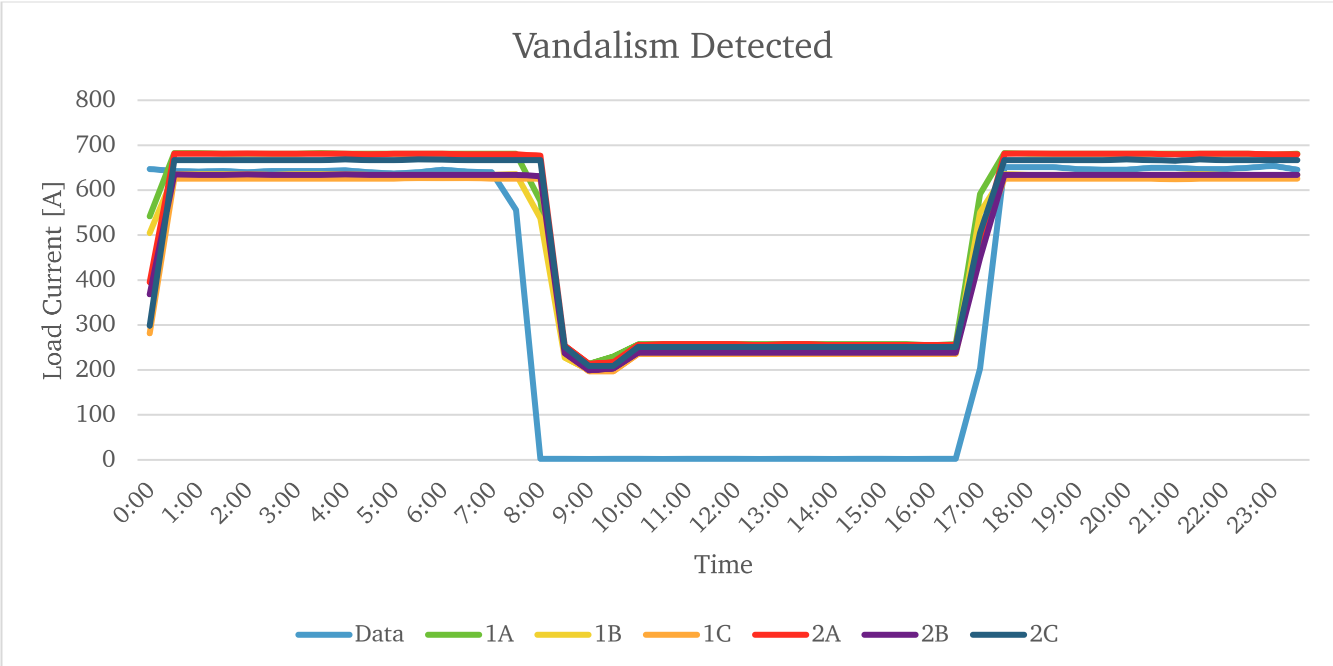

Figure 4 Abnormal and normal streetlight load profile during the Winter. "Data" plots the load profile provided by Athena Power, while the Rogowski coils are represented by "1A", "1B", etc.

It is clear in Figure 4 that the load is not following the correct profile from 8:00am to 4:00pm. When the load should be zero, it is actually drawing about 250A for that period of time. The UFD 1000 device could be a tool for field technicians to identify which transformers are not following an expected load profile.

Conclusion

The UFD 1000 performed well during the anomaly detection test. This application could be used by utility technicians to track the load profile of different transformers that might show abnormal load demands, or it could be built into cybersecurity application.