Recurrent Outage Baffles Crew

DFA Technology Puts End to Three-Month Problem

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In September 2004, lights went out at several residences fed from a single-phase 50-kVA pole-top transformer on a 13-kV circuit in Staten Island, New York. Con Ed field personnel found that the secondary breaker of the CSP transformer at this location had tripped. At this location, secondary service cable from the transformer went down the pole and into a buried connection box at the base of the pole. A "crab" in the buried box connected this supply cable to three direct-buried service cables, each of which fed a customer meter. Personnel found no evidence of a problem, and reset the transformer breaker. The unit remained closed with all affected customers in service and no reports of flickering lights or partial service.

Over the next three months, however, the same customers experienced additional outages. Each time, customers reported a lights-out condition, and field personnel responded. Each time, the secondary cables showed no evidence of a problem, and after the transformer was reset, service was fully restored. The problem continued until December, when engineering and field personnel teamed up and used Distribution Fault Anticipation (DFA) technology to help them diagnose the problem.

Con Ed participates in the DFA project that EPRI sponsors at Texas A&M University. The DFA Prototype at the source substation recorded multiple episodes of low-level arcing leading up to and coinciding with the outages at this location. Figure 1 illustrates the primary feeder currents that the DFA Prototype recorded at the substation during one early episode. Over the next three months, some of the arcing episodes caused outages. Others, such as the one shown in Figure 2, arced briefly and then self-extinguished without causing outages.

Just after midnight on December 7, 2004, the customers with the troublesome service reported what turned out to be the final outage. Having recently become aware that the DFA was reporting a problem, field personnel gave notification of the outage to the engineer with access to DFA reports. He checked DFA records and found that the arcing episode of Figure 3 corresponded to the reported outage time.

At this point, the relationship between the arcing episodes and the recurrent outages was discovered.

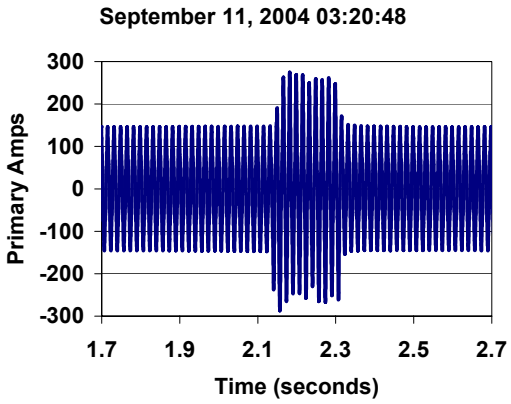

Figure 1. Arcing was too small and short-lived to be noticed by conventional means.

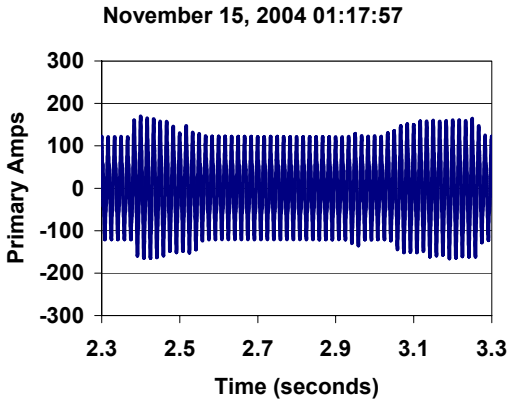

Figure 2. More than two months later, the DFA continued to report intermittent arcing.

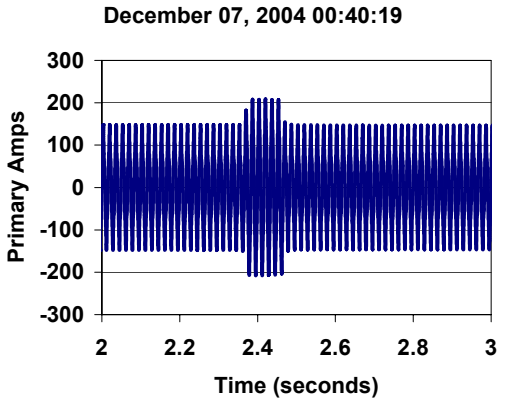

Figure 3. DFA's report of arcing coincided with lights-out call.

Figure 4. Excavated cables don't appear capable of serving load – but they were!

Field personnel deenergized the buried box and the underground service cables, and installed temporary overhead services to affected customers.

In the weeks before personnel took the cables out of service, the DFA had been reporting arcing frequently, with the intervals between successive reports ranging from just a few hours to as much as a few days. After personnel deenergized the underground cables, the outages ceased and the DFA stopped reporting arcing, thus confirming that the problem had been identified and eliminated.

When personnel later excavated the underground cables, the extent of their damage surprised everyone. Figure 4 shows the physical condition of one section of cable. In the figure, the two black cables are the live legs and the yellow cable is the neutral conductor.

The photographs show very significant damage. A single, brittle strand of the neutral conductor that is shown remained intact while the cable was in service, but broke after excavation. The photograph on the right side of the figure is a close-up of one of the live legs, and shows that the aluminum conductor was entirely missing for a span of almost an inch.

Field personnel excavated all of the affected cables. They found the supply cables up to and inside the crab to be in good shape, but each of the three underground cables between the crab and the customer meters had numerous places with damage similar to that shown in the photographs. What is truly amazing is that these cables actually continued to carry electricity and serve load!

It is important to realize that events like the ones involved in this case often increase total feeder current only slightly, thereby mimicking load. The DFA's signal processing techniques automatically analyze these small changes, classifying them as arcing and discriminating them from normal load and from other normal and abnormal phenomena.

A fair and obvious question is, "If the DFA was reporting arcing all this time, why didn't someone realize the correlation between the arcing episodes and the outages sooner, and resolve this before three months passed and multiple outages occurred?" Here's the answer: The DFA Prototype at the source substation is part of a research project. As such, it is not integrated into normal operations and its information is not available to field personnel. In addition, there was a problem with the third-party Internet service that is used to retrieve data from the substation. As a result, the DFA captured numerous arcing episodes throughout this period, but the data could be accessed only by visiting the substation, which was done only infrequently.

Con Ed's engineer became aware of the DFA's arcing reports when Internet service was restored in November. After reviewing the backlog of arcing reports, he inquired of operating personnel to determine whether they were aware of any chronic problems that might be responsible for recurrent arcing. The inquiry made operational personnel aware of the activity that the DFA was reporting. As a result, when the December 7 outage occurred, field personnel made the engineer aware of it and, working together, they solved the problem.

This example shows how DFA technology helped Con Ed solve a problem that had troubled them and their customers for several months. Perhaps more importantly, cases such as this are gaining enthusiastic buy-in of DFA technology, both by engineering personnel and by field operating personnel. When unusual problems arise, personnel are starting to ask, "What did the DFA say?"