FLUKE®

Performing power quality studies and troubleshooting loads

Application Note

Field Applications

Case Study

Tool: Fluke 1735 Three-Phase Power Logger

Profile: Mac McArthur, power quality consultant

Tests performed: Tracing and isolating harmonics; verifying voltage drops.

Working from his offices in Puyallup, Washington, just east of Tacoma, Mac McArthur performs power quality studies for commercial, industrial, and residential clients. He also serves as an agent for the commissioning of electrical systems in new buildings and the retro-commissioning of older buildings.

Prelude to a power-logger purchase

In late 2006, McArthur found himself in the middle of a challenging assignment. The subject of his investigation was a facility that makes corrugated paperboard and whose electrical load was handled by a 1,500 kVA transformer owned by the local utility. The transformer, a 277/480-volt, 4-wire, Wye, had failed because of thermal stress with only a 65 percent load on it. The utility hired McArthur to find the cause of the failure.

"I went in with my basic instruments, including a single-phase power quality analyzer and my Fluke 189 (true-rms) Digital Multimeter, but I ended up renting an expensive power logger—a black box that allowed me to see what was going on, but would not allow me to zero in on just the parameters that interested me," McArthur explains. That meant a lot of data he didn't need, filling up the memory too fast. And without a screen on the unit, he couldn't verify the setup.

Using his instruments and the rented power logger, McArthur determined that the problem was on the customer side of the transformer. Of course, the utility required that the company correct whatever had caused the transformer failure in order to avoid burning up another one. So, the company retained McArthur to diagnose the problem.

"To put it in numbers," McArthur says, "the transformer is good for approximately 1,800 amps. The company was drawing between 1,100 and 1,200 amps at full load, but the environment was full of dc drives. We noticed that dc current was saturating the transformer's core with all of the equipment on. This condition was evident because the even harmonics were higher in amplitude especially the 2^{nd}, 4^{th} and 6^{th} harmonics. Further testing showed that the transformer's output voltage was approximately six to eight volts lower because of the core saturation. That was a problem."

McArthur started taking readings at the service entrances and went from there down to the equipment—the individual loads. He found a relatively high dc component being reflected back to the transformer and set about to isolate the source.

Initially, the consultant identified one drive as a source of wayward dc current. It was a die cutter's drive that was reflecting a considerable amount of the second and fourth harmonics back into the distribution panel and from there into the transformer. These even harmonics indicate the presence of dc. Therefore, at McArthur's suggestion, plant personnel replaced the more-than-20-years-old offending drive with a more modern unit.

"We thought that would take care of the issue," McArthur says, "but when we started looking at the main service scan, we saw that we still had just about the same amplitude for dc current, indicated by the second and fourth harmonics. So, we had to isolate another machine as the source of the additional dc."

Using the instruments at his disposal, McArthur pinpointed the culprit: another die cutter with a drive similar to the first, and he recommended its replacement. Company officials, however, wanted proof that changing out this second drive would be the final step in protecting the utility's transformer. During the first upgrade, interfacing the new drive and its controller with the existing die cutter had been a technological challenge, and the whole project was quite costly. The company did not want to repeat the same process without being sure that the upgrade would accomplish what it was intended to.

Purchasing a power logger

While the initial tests, the first upgrade, and subsequent tests pinpointing the second machine took place, McArthur looked for a power logger more suited to this kind of work. He wanted an affordable instrument that would provide the baseline findings he was looking for and provide concise reports on only the parameters that interested him. His search led him to the Fluke 1735 Power Logger, an affordable instrument developed for consultants like him as well as plant electricians and electrical installers, all of whom have occasion to investigate and correct disturbances in power distribution systems and who would benefit from owning, rather than renting, a logger.

Not only was the recently introduced Fluke 1735 capable of detecting and displaying the harmonics that were creating havoc in the paperboard company's electrical distribution system, McArthur saw unlimited potential for it in his commissioning work as well as in load studies and energy-use assessments. In addition, the instrument could capture voltage events—sags, spikes and interruptions.

In McArthur's own words, "The 1735 promised to be very useful in harmonics environments. Using the software that comes with the instrument, I would be able to isolate each harmonic if I wanted to and do a trend plot or histogram. But on this particular job, all I had to be able to do was to see the actual amplitude of the second and fourth harmonics on the customer's transformer."

Meanwhile back at the plant

McArthur obtained a Fluke 1735 Power Logger and put it on the main transformer at the paperboard plant. He then turned off the suspect die cutter and sampled the electrical environment. With the die cutter not running, the second and fourth harmonics were essentially nonexistent. However, when plant personnel turned the machine on, the second and fourth harmonics went from almost zero amps to between six and 13 amps.

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"That proved right then and there that this machine was our culprit," McArthur explains. "We needed to have its drive system brought up to date using today's technology. We had to get rid of those second and fourth harmonics. We knew that once those were gone the transformer would perform the way that it should. And that's what happened."

Finding the cause of voltage drops

In another case, McArthur used his recently acquired 1735 Power Logger to help a homeowner place the cause of lights dimming and computer screen fluctuations squarely on the shoulders of her electric utility. Because of local zoning laws, McArthur's client was not permitted to tear down her existing home to build a new one. As a result, she added 3,000 square feet to her home. She uses the addition as her primary residence while the older dwelling has become a "mother-in-law apartment" or, in this case, a rental apartment.

The consultant determined that the total calculated load for the two dwellings is 305 amps. The meter base is rated at 400 amps. However, the utility is supplying the housing units with only a single-phase 25 kVA transformer having a full load rating of 104 amps.

"The problem," McArthur reveals, "is that she has a four-ton heat pump. Every time the heat-pump motor starts, the locked rotor amps (LRA or motor inrush) is 140 amps. When we considered the fundamental load and did the math, it was pretty clear what we were going to see when the motor started: The lights dim because the instantaneous voltage drop was five or six volts (during each episode)."

The client also reports that depending on the load on the transformer, not only do her lights dim but the computer screen in her home office sometimes shrinks slightly when the heat pump comes on. McArthur explains that utilities often load a 25 kVA transformer up to 200 percent of capacity. He says that the loading on the transformer supplying his client is more than that—205 or 209 percent at peak times.

"I kept telling the utility that for a nice steady-state rms load they might get away with this way of operating," McArthur reveals, "but any time you inject a motor starter or something that takes an instantaneous high current into the system, you are going to see a voltage sag. The sag will manifest itself in the lights. The utility kept telling my client, 'The problem's in your home.'"

The consultant made an agreement with the homeowner that he would monitor the electrical system at the meter base to see "what's being delivered and what the effects are." He attached the power logger for a week's worth of monitored data.

McArthur found that the voltage sags were averaging three percent and happening at a rate of two to three per hour. McArthur believes that his findings will require his client's utility to address the problem and upgrade the transformer, but he also proposes additional tests to augment his findings.

"The 1735 did a beautiful job during the 7-day test," McArthur says. "Using the instrument and its accompanying software, I was able to average events over the two-minute, 20-second sample period. But I want to go back and do at least one more test."

McArthur plans either to do one-second sampling for a couple of hours or to sample in the "event" mode. He explains that in his initial sampling, the interval of two minutes and 20 seconds represented a considerable number of cycles. He believes that by using one-second sampling, he will be able to get down to 60 cycles and "see" the sags in real time. Then, the sags will, in McArthur's own words, "show up deeper." Regarding using the events mode, McArthur says that he should be able to set up to detect each sag when it occurs, with similar results—sags represented as deeper.

At this writing, the 1735 is so new to McArthur that he is still exploring its capabilities. Still, he anticipates many uses for the 1735 Power Logger in his day-to-day work. He is especially interested in the instrument's ability to log power every 15 minutes for 30 days, on the same schedule that utilities use and the National Electric Code specifies.[1]

1For details about using the Fluke 1735 Power Logger in this way, see the Fluke Application Note, "30 Day Load Studies with the 1735 Power Logger"

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Web access: http://www.fluke.com

Printed in U.S.A. 5/2007 3034602 A-EN-N Rev A