FLUKE®

Tips and tricks from the trenches

Application Note

Testing Functions
Case Study

Tools: Fluke 568 IR Thermometer, Fluke 345 Power Quality Clamp Meter

Operator: Jim Turner, technician, James and Sons Electric Ltd.

Measurements: Heat from electrical resistance; three-phase current; power factor

Where the lack of a tool can mean a lost opportunity

Heat, buzzing and indeterminate noise make electricians wary of what lies below. In this business, intuition goes a long way in dealing with anomalies. According to Jim Turner, in his 30 years of experience in the business, some things haven't changed much. "You've got symptoms, you've got intuition, and you've got tools to hunt down problems." Turner, a technician with James and Sons Electric Ltd. (Quesnel, British Columbia), gets his share of late night calls. Not surprisingly, many involve a critical issue that could result in forced downtime and a hefty repair bill—or a hefty surcharge from the local hydroelectric power utility.

"It's all about prevention," says Turner. "I got a call at about 10:30 p.m. one night from a bakery, when they were just starting to bake for the night. The customer said he was not getting all the power he typically gets from a 200 A, three-phase switch. When I arrived, I found that the fuse on one of the three phases had blown. It turned out that there was arcing taking place from a loose connection and that, of course, increased the resistance. The problem had compounded itself until the combined heat and current took the fuse out."

The heat is on

"The heat had been so intense that it had actually fused the switch closed. I couldn't even open it up until I had gotten the guys from the hydro utility to come pull the meters. Then, of course, everything was dead—which brought operations to a halt—but that allowed me to break open the case and find out what I could do from there."

Turner muses at what he could have done if the bakery had used a preventive maintenance approach. "Proactively, and before the first symptoms had become severe, I could have used an IR thermometer to measure the difference in temperature on the three phases. I could have spotted the problem instantly."

Balancing act

But what's the issue with a loose connection, and how can the problem mushroom into a virtual meltdown? "A connection on the bottom of the fuse could be good and tight," he says, "but if the connection at the top is loose, that will cause a greater current draw and more heat. That condition can cause the current to increase until it's akin to running a miniature arc welder at that one small spot!"

Jim Turner comparing infrared heat signatures across three phases.

Turner now has a Fluke Model 568 IR Thermometer, which has a 50-1 D:S ratio. "In other words, at a distance of 50 feet, I could pinpoint the problem to within a one foot circle. At 50 inches, I could pinpoint the problem to a one inch circle. That narrows my field pretty tightly!"

Would Turner have been able to use a clamp meter or multimeter to check current across all three phases and determine whether a problem was brewing? "There are multiple conditions that can cause a problem, and one of those is excess current, even in the absence of excess heat. In testing the switch, I would be able to see whether or not the three phases were balanced." Ideally, he says, the three would be as close as possible to a balanced condition. But he adds—almost as a watchword—that it's important to measure or calculate the currents on the three legs at full load.

"For example, if all of the machines that could be turned on had actually been turned on at any given time, and we had measured the three currents, we might have seen that one of the legs was carrying more than 30 A above the other two. If possible, shedding one of the other smaller loads from that phase and placing it on another phase for better balance would be a wise remedy."

Power quality determines power costs

According to Turner, power quality is shaping up to be another determinant of system efficiency and operations. The reason? Power factor—a reference to how efficiently a circuit uses the current applied to it to do work—suffers as the number of nonlinear loads in the circuit increases. Nonlinear loads are loads in which current and voltage are out of phase with each other. "With low power factor, less work can be derived from the supplied current," he says. "Hydroelectric utilities levy a surcharge on a plant that has low power factor."

Turner lays out the challenges of low power factor. "A power quality analyzer will show me actual power factor on the load—which is what the plant manager needs to see before he gets the utility bill. Today, I get a call from a customer, and he's likely to say 'I'm getting charged a premium for my power usage, whereas just last month I was paying far less for operating the exact same equipment."

What is power factor?

There are three different ways to measure power: active power, measured in watts (W or true power); reactive power, measured in volt-amperes reactive (VAR); apparent power, measured in volt-amperes (VA).

Active power (W) or true power = useful work

Utility charges are based on watts. This is the amount of power it takes to do a given amount of work. Watts are simply voltage times current, or E x I.

You may need to consume more current, due to the amount of reactive power in your system. This means you will draw more watts to do the same amount of work.

Reactive power (VAR) = necessary overhead

This is the power that energizes the magnetic fields of inductors (coils), and charges capacitors. Thus, motors, transformers, and capacitors all require VARs.

The charging and discharging of the magnetic fields occurs within each half cycle. Power engineers speak of motor loads as consumers of VARs and capacitors as suppliers of VARs. Reactive power is unavoidable overhead in ac power circuits.

Apparent power (VA) = system capacity

VA is a measure of system/equipment capacity. Transformers are sized in VA or kVA, not in watts. Even though VARs are overhead, the system VA must be capable of supplying the VARs and watts required.

Power factor (PF) = W/VA

Remember, watts measure useful power while VA measures supplied power. Thus, watts/VA is a way of saying useful power/supplied power.

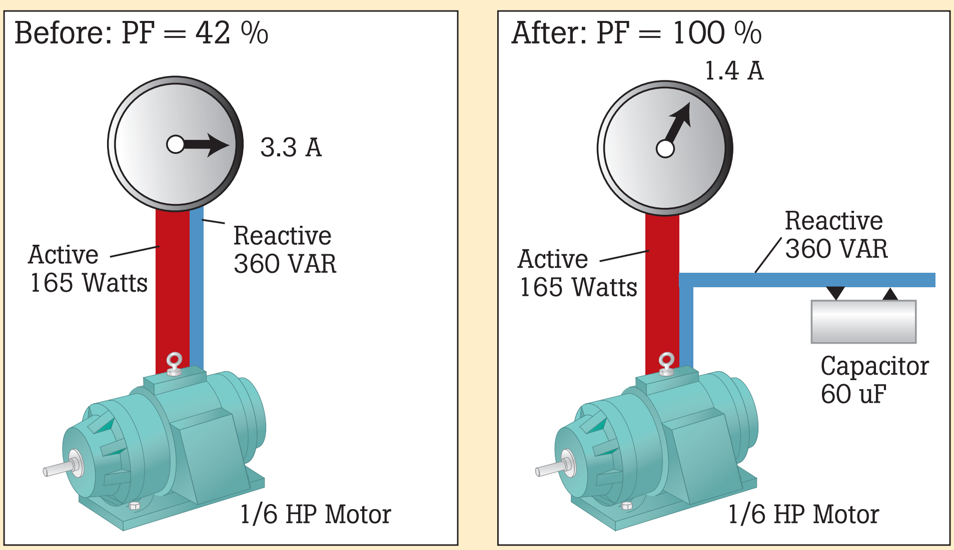
With a power quality analyzer, Turner says, the user can view phase angles and determine how close the circuit is to "unity," or 100 % power factor. "That's what we strive for—when voltage and the current are completely in phase with each other. But when the current shifts and it becomes out of phase with the voltage, the meter will show the user a leading or lagging power factor. If it's lagging, it takes more juice to produce the same amount of work than it would if current and power were in phase. And that's why the electric utility dings the customer with a surcharge."

Capacitors provide "correction"

While power factor is a constant concern in any plant or facility with nonlinear loads, plant technicians can mitigate that concern by understanding the role of the capacitor in power factor correction. Power factor correction capacitors reduce the total current drawn from the distribution system and subsequently increase system capacity by raising the power factor.

A good example of the need for power factor correction, says Turner, is the city hall building in his small British Columbia town—a five-story building with two swimming pools and associated pumps and heaters. The building also has two elevators and 16 recently added water-source heat pumps on the top floor. All of this, he says, is in addition to office lighting, computers, and air conditioning systems.

"The city works foreman called us in to replace the capacitors providing power correction because their hydroeloectric bill had gone through the roof. The original capacitor bank had failed." At the time, he said, he did not have access to a power



Power factor correction

The illustration above shows how capacitors act as kVAR generators.
They are localized sources of the kVARs that motors require to power their magnetic fields.

- In this example, the "before" motor has all its VARs supplied from the upstream system
- The load demands 165 W and 360 VARs from the system, which equates to 3.3 A (VA = 396, PF = 42 %)
- The "after" motor has all the VARs supplied locally by the 60 microFarad capacitor. PF = 100 %. The system has to supply only 1.4 A (168 VA)
- Because the capacitors supply VARs locally, they relieve the upstream system of the burden.
- Correct capacitor sizing requires PF and kW measurement
- Never add capacitors to a circuit containing an electronic motor drive without first consulting with the drive manufacturer

Taking a 208 V measurement on one leg of a three phase circuit for a roof-top HVAC unit.

quality analyzer and therefore chose to replace the existing capacitor bank. "We really needed a tool to help determine how the power factor in the building had changed now that the pools were no longer in use. And how much of the power factor problem was resulting from computers and electronic-lighting ballasts? We couldn't be sure if the size of capacitor we installed was going to be exactly what was needed."

But can the power quality analyzer tell the technician what kind of power factor correction is required? "The analyzer will give you a kVAR value to tell you how much the power is actually lagging. When you get that kVAR reading, you can plug it into an equation that will then tell you what level of kVAR correction you need to apply."

Turner says that no matter how sophisticated the tools are that his team uses, they still rely on a disciplined process of elimination to pinpoint the problem. "You can always start swapping stuff out, but it's going to be really expensive and really time-consuming—or, worse, you'll find that you're tackling the wrong part of the system! We have tools like the power quality analyzer to avoid this trial-and-error process, and today we have tools that log the results for uploading to a computer. We think it through, we use the tools, and we just might find the solution staring us in the face on a computer monitor."

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