Circuit Monitoring Maintains MRI Uptime at Washington Hospital

Kadlec Regional Medical Center avoids excessive maintenance costs through innovative solution

Magnetic resonance imaging (or MRI) has long been a powerful non-invasive tool to help doctors provide as accurate a diagnosis as possible for patients, particularly those suffering from very serious medical conditions. Because time is of the essence for many patients, the uptime of MRI machines is crucial, so doctors can study the images they produce and prescribe a course of care as quickly as possible.

Located in Richland, Wash., Kadlec Regional Medical Center has developed a reputation as the region's premier chest pain center, with growing renown as a neuroscience hospital. Among its most important pieces of equipment is a 3 Tesla (or 3T) MRI machine, which provides images that are even more detailed than the center's computed axial tomography (CAT) scan and 1.5T MRI machines. Kadlec Regional Medical Center is the only hospital in the region with a 3T MRI, so it handles a virtually constant stream of patients on a daily basis, some from hundreds of miles away, making uptime doubly important for the facility.

A 3T MRI machine's solid-state electronics and computers are critically important in facilitating patient images. When Kadlec Regional Medical Center's 3T MRI machine was installed in 2005, the manufacturer recommended a very extensive, and costly, regimen of equipment solutions to protect the electronics, including an uninterruptible power supply (UPS). There didn't seem to be much of an alternative – after all, downtime would put patients at risk, especially because some of them were coming from a great distance. But the down side was the solution's exorbitant initial cost – more than $100,000, an amount perhaps exceeded only by the cost to recalibrate the machine if that measure wasn't in place.

After examining the situation from multiple angles, Kadlec Regional Medical Center electrical leader, Jason Rose, conferred with a colleague from Schneider Electric that had experience in the microelectronics manufacturing industry. Together, they developed a more cost-effective solution that employs a Square D® PowerLogic® CM4000T circuit monitor that constantly monitors voltage from the 3T MRI machine's two main electrical feeds. They developed specific values based on the Information Technology Industry Council (ITIC) voltage curve, typically used by the electronics industry to help ensure reliable operation of computers and other devices. If the voltage feeding the 3T MRI machine swells above or sags below the ITIC curve, the circuit monitor sends a signal to open two shunt-trip circuit breakers (150A and 60A), thus taking it completely offline and avoiding cooling system or electronic component damage, recalibration, downtime and cost. The monitoring system's automatic paging notifies electrical staff of a power quality event immediately for reset and analysis.

"It was a new, innovative idea that helped reduce the cost of healthcare, increased reliability and reduced damage due to poor power quality," says Rose, who has since been promoted to project coordinator. He adds that the overall cost – including the circuit monitor with transient voltage surge suppression and shunt-trip circuit breakers – was just 25 percent of the UPS-based solution the 3T MRI machine manufacturer recommended, but results are comparable. It is operating at 98 percent efficiency, which is what would be expected with the originally recommended solution. Plus, the circuit monitor's software is the same as all other circuit monitors installed throughout the center, thus creating a network of devices that monitor status and generate reports, and facilitating a holistic view of the center's power quality at any given time.

Balancing costs

Kadlec Regional Medical Center is a non-profit, 188-bed hospital that serves the Tri-Cities area of southeastern Washington state, including the communities of Richland, Kennewick and Pasco, along with northeast Oregon. For in-patient, non-invasive procedures, it utilizes two CAT scan and two MRI machines, including the 3T MRI. Two more MRI machines are located at a nearby outpatient facility. The 3T MRI machine is a closed-bore model, meaning the patient lies on a table that slides into the bore, which contains a rotating superconducting magnet bathed in helium. The helium treatment drops the magnet's temperature to roughly 450 degrees Fahrenheit below zero, reducing the resistance of the wire that powers the magnet in the imaging portion as close to zero as possible.

But just as important are the solid-state electronics and computers that operate the 3T MRI machine, which like all electronics contain internal power supplies that are sensitive to poor power quality, like voltage sags and swells. What's more, if the 3T MRI machine is operated outside of normal expectations – including substandard power quality – the manufacturer warranty is voided.

Rose wasn't involved in the 3T MRI machine's installation in 2005, but he was part of the team responsible for facilitating its electrical distribution. In effect, his team was also responsible for minimizing future downtime occurrences, so that weighed heavily on his mind when reviewing the manufacturer's recommended equipment and design specifications. That included line isolation and a transformer designed to ensure voltage wouldn't sag or swell by 10 percent either way, along with the UPS – all of which came with a hefty pricetag.

After careful consideration, Rose started thinking about less-costly alternatives that also wouldn't affect reliability. That led him to contact Schneider Electric Regional Engineering Team leader, Jonathan Clough, who happened to be working on an unrelated project at Kadlec Regional Medical Center at the same time. Clough had extensive experience in the microelectronics sector, which is heavily focused on maintaining power quality to enhance the manufacture of products like processors and computer chips.

Clough agreed with Rose's assessment of the situation, pointing out that a UPS is only as reliable as the batteries that power it, which require frequent and time-consuming testing. Plus, a UPS would have been costly in terms of physical space, in addition to budget. They began discussing alternatives, and concluded that the key was the 3T MRI machine's computers and their toleration for voltage abnormalities, which suggested power monitoring as the most viable solution.

Through his experience in the microelectronics industry, Clough was intimately familiar with the Computer Business Equipment Manufacturers Association (or CBEMA) voltage curve, a voltage region calculated by the organization that afforded the best operating conditions for power supplies built into electronic devices. But they also discussed the ITIC voltage curve (so named because CBEMA eventually became the Information Technology Industry Council). The ITIC curve can be considered a more stringent version of the CBEMA curve and is used by the semiconductor industry for the manufacture of single-phase power supplies for copiers, fax machines and computers … such as those used by the 3T MRI machine. Clough theorized that the voltage of the electricity being fed to the 3T MRI could be monitored based on the ITIC curve, and if the machine deviated from those values, the circuit monitor could be configured to trip the breakers and take the machine offline, thus helping to avoid potential damage, downtime and cost.

"Computers and sensitive equipment need a voltage standard in order to operate reliably," Rose explains. "When CBEMA developed its curve, they did many studies on where equipment failed and then came up with a voltage region over a certain amount of time that's an acceptable level to maintain that reliability. In the short-term – microseconds and milliseconds – you have a higher tolerance, but if you have a major spike, you can damage the equipment.

"CBEMA put a little bit more technical, case-by-case research into the ITIC curve," Rose says. "The ITIC curve doesn't cover all equipment, but it more accurately covers a single-phase 60 Hz power supply, for computers. It sounded logical. I talked to the manufacturer of the 3T MRI and gave them the gist of what we were doing, and they said it should work."

Unexpected voltage sag

The next step was getting approval from Kadlec Regional Medical Center leadership to implement the plan, especially vice president Dave Roach, who oversees information technology. Because Roach also has an engineering background, he was able to understand the logic behind what Rose was proposing. Once his buy-in was secured, the next step was to program the ITIC voltage curve into the Square D PowerLogic CM4000T circuit monitor.

Before any testing or simulation could commence, however, a voltage sag occurred, caused by the local utility. But the system worked as planned – the circuit monitor recognized the voltage abnormality and sent a signal to the circuit breakers to trip, thus taking the 3T MRI machine offline. Subsequent review of the voltage waveforms that the circuit monitor recorded at the time proved that the voltage had moved outside the ITIC curve.

"It was theory prior to that incident," Rose recalls, "but the system saved the equipment, and it proved to the leadership that it could be done."

It also prompted the next logical step – applying the system to the other MRI and CAT scan machines, both at Kadlec Regional Medical Center proper and the outpatient facility. Unfortunately, this was helped along by another voltage sag that occurred during the same time frame, with very different results. Without a circuit monitor pre-programmed with the ITIC curve values, the MRI machines there, along with other pieces of equipment, operated for several minutes after the voltage sag occurred; the resulting damage cost hundreds of thousands of dollars to correct, not including downtime.

While providing the impetus to expand the system to all MRI and CAT scan machines, the second voltage sag incident also behooved Rose and Clough to institute a more comprehensive testing mechanism, to verify that the system would operate similarly on all machines. Clough worked with colleagues to develop a device that included a circuit monitor and a relay test set that could be programmed to follow the ITIC curve and contour breaker trip points based on the severity of the voltage deviation. Essentially, because the circuit monitor has multiple I/O capabilities, it allowed for three different trip levels to be programmed based on the ITIC curve – the highest trip point for the fastest, most severe voltage deviations that require equipment to be taken offline instantaneously; the lowest trip point for gradual deviations; and a third trip point between the highest and lowest. Testing was done after hours, to avoid interfering with patient appointments.

With testing complete and accuracy of the time delays documented, the appropriate trip points were programmed into the circuit monitors for the MRI machines at the outpatient facility. The final job was to return to Kadlec Regional Medical Center and verify the same values were programmed into the MRI and CAT scan machines there, and complete appropriate testing. All equipment passed, including the 3T MRI machine.

Power quality accountability

Rose says the success of the project has not been lost on Kadlec Regional Medical Center's leadership, mainly due to reduced maintenance, which directly affects the cost of healthcare.

"The technical side kind of puzzled management, but when we have power quality events, they aren't seeing the maintenance bills from that," he says. "We never had a way to identify substandard power quality before, so we were at the mercy of the manufacturer to cover the cost if there was an incident. Now, we're in the driver's seat – we have the data that shows, 'This is what happened, and it was outside of the voltage range.'"

But from a more practical standpoint, Kadlec Regional Medical Center's MRI and CAT machines, including the 3T MRI, operate virtually non-stop eight hours each day. That means they are handling a constant flow of patients, many of whom are wondering what is ailing them or if their treatment plan is working. Having a 3T MRI machine that operates 98 percent of the time means those patients are better served. The fact that the idea represented out-of-the-box thinking also fit well within the center's corporate philosophy.

"Kadlec Regional Medical Center has always embraced innovative ideas," Rose says. "Patient safety is obviously the most important, but if there are new ways to benefit healthcare, we're for it."

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