Wrong Prognoses Aggravate Medical Imaging Problems

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Medical imaging systems need protection from the effects of power outages, transients and poor wiring practices. But, sometimes the symptoms lead to the wrong diagnosis or the wrong solution resulting in a condition worse than before. Four examples show that the imaging equipment got worse because of the treatment.

Four case studies show that medical imaging systems require special consideration from both the electrical system and its power conditioning equipment.

Case 1: Extra Voltage Regulation Blurs X-Ray Images

On older X-Ray systems, motor-driven autotransformers provide power to produce the high voltage (typically 100kV) needed by the tube. These devices correct for slow moving facility voltage swings and can regulate the output voltage at various kilovolt levels. A gain stage in the regulator assembly compensates for voltage drops in the power distribution system, which vary from site to site.

A tap-switching regulator with ±3% regulation, installed ahead of an older X-Ray system, attempts to correct any voltage deviation, whether it is line or load induced. Because X-Ray equipment can easily cause a 5-10% voltage drop, the switching of taps during an exposure is likely. Changing taps results in a 5% or more increase in voltage. Unfortunately, older systems expect to see a voltage drop and have no means to compensate for fast voltage

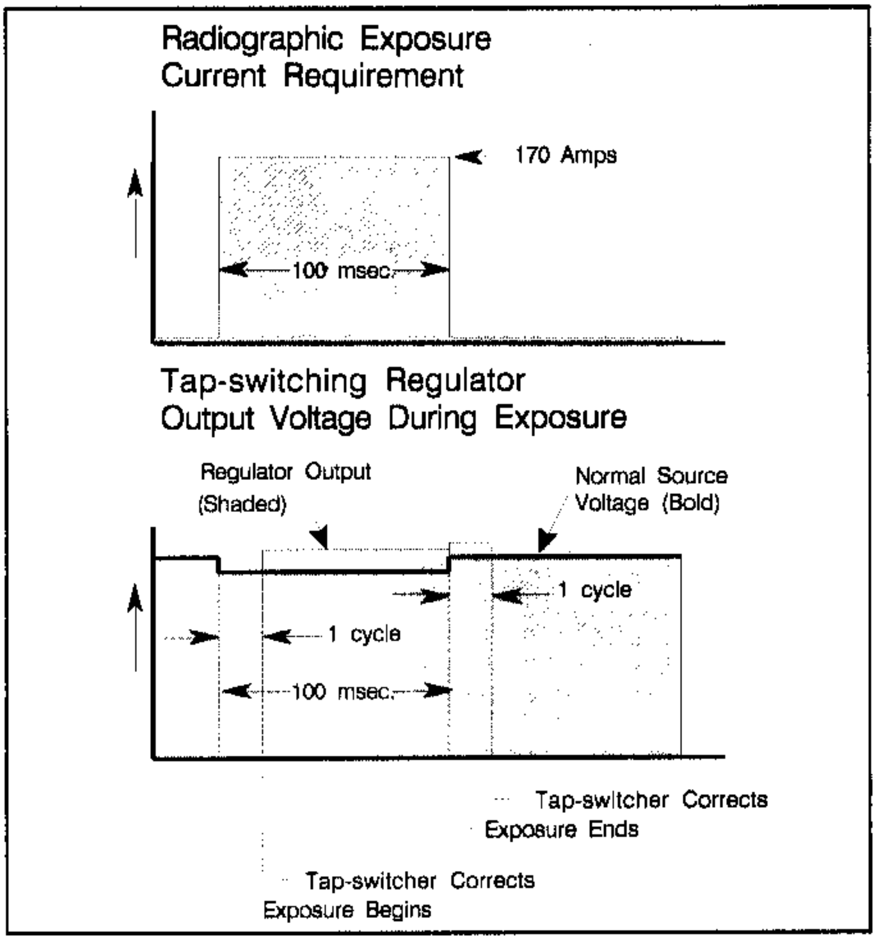

Figure 1. Figure 1. Unpredictable X-Ray Exposure.

Case Studies

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changes during exposure. The consequence of the voltage compensation is an unpredictable X-Ray exposure (*Figure 1*).

In one case, the manufacturer of a tap-switcher modified their equipment to lock out regulation during the exposure. However, this involved so much time and effort by the facility, X-Ray manufacturer and conditioner manufacturer that the facility could not use its imaging system for several months – an unnecessary inconvenience.

In a similar situation, a vendor sold a hospital a "Power Synthesizer" to power an older-design X-Ray machine. Unlike a tap-changer, a synthesizer doesn't regulate voltage in steps, but it does "ring" for up to 100 milliseconds when a large step load is applied. Because the X-Ray exposure takes only 100 milliseconds, the output voltage is unstable throughout exposure. Synthesizers cannot be disabled during exposure, as the tap-changer was in the previous example, so the only solution was to remove the device completely (*Figure 2*).

Case 2: Undersized Magnetic Components May Saturate

Because the average power drawn by the X-Ray equipment is very low, the National Electric Code allows many distribution components to be derated (NEC 517-72 and 73). These components include overcurrent protection, switches and conductors (to 50% of the instantaneous current required during exposure). Unfortunately, many power conditioners are sized for the circuit breaker rating and ignore the specifications of the X-Ray equipment. The result is an undersized power conditioner that may see 200% of its load rating during exposure periods.

Here, a 100A filter, using a coupled inductor for common mode attenuation, fed an X-Ray system that required 170A, maximum. The vendor selected the size of a filter based on the 100A panel breaker. During high-power exposures, the coupled inductor saturated, producing a large voltage drop between phases and over 10V from neutral to ground. This voltage fluctuation caused inconsistent exposures. At maximum power, the X- Ray system shut down completely because of the voltage drop (*Figure 3*).

A proper solution may have been to use a filter designed for the maximum current, but in this situation, high frequency noise was not present anyway so the filter was removed. In its place, the facility installed a parallel-connected TVSS that provided voltage clamping of transient impulses but no high frequency filtering. The cost was also significantly lower than the filter.

Case 3: UPS Both Under- and Over-Rated

Manufacturers often tout their Uninterruptible Power Supply (UPS) as the complete solution to power problems, but here the UPS was unable to protect a CT Scanner from itself. The CT Scanner required exposure power of 80kVA and was powered from a 125kVA UPS. Not factored in was the half cycle startup power of 150kVA needed to charge the capacitance inherent in the system's high voltage cables. The UPS was a static, on-line device which saw this 150kVA load as a threat to the output inverter and switched to bypass mode during every exposure. This meant the CT Scanner couldn't be used to create images during a commercial power outage because when the transfer to bypass took place, the UPS shut down. This obviously defeated the whole purpose for installing a UPS.

The UPS manufacturer attempted to modify the sensing circuit to ignore the half cycle surge but was unsuccessful. Finally, after considerable time by both the CT Scanner and UPS manufacturers, the entire inverter section of the UPS was replaced with one rated for 200kVA. This eliminated the problem of switching to bypass.

On one hand, the UPS was underrated, on the other it was really overrated. The main goal of a UPS is to protect sensitive electronics and keep critical data from being lost. These functions could have easily been done with a properly applied UPS of only 15kVA. Of course, no exposures can be taken during an outage, and those in the process will be lost, but the cost of a lost exposure versus the cost differential between a 15 and 200kVA UPS is minor.

Another money-saving aspect is battery sizing. If the user feels the need for total UPS protection and sizes it for the maximum inrush current, the battery capacity only needs to be one-tenth of the capacity needed for a typical data processing application. Usually, a CT Scanner uses only 10% of its rated power during standby mode, so sizing the battery bank for 100% load for 10 minutes allows an hour and a half backup under normal CT Scanner operations. On-site emergency generators eliminate the need for such a lengthy backup time.

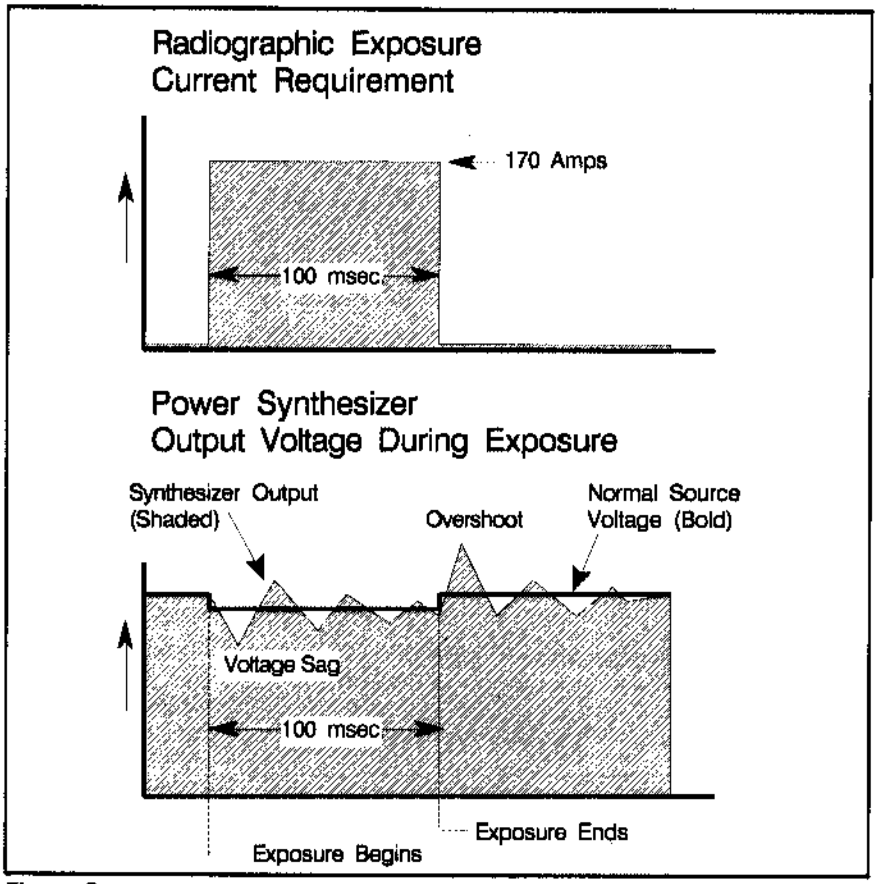

Figure 2.

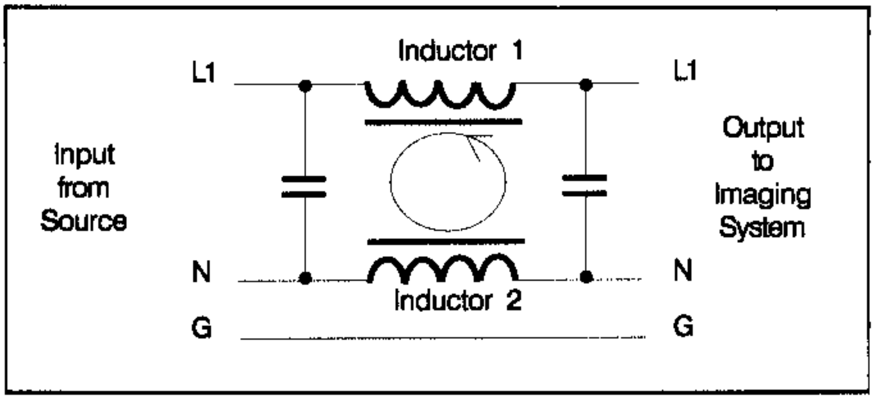

Figure 3.

Case 4: Low Standby Currents Confuse Zero-Crossing Switch

Tap-switching regulators often sense output currents so they can perform their switching at the zero crossing. Although X-Ray systems need 150-200A during exposures, they draw only 3-5A during standby. Therefore, zero-crossing switches may have difficulty resolving currents during standby.

In one case, a tap-switching regulator supplied power to a modern, converter-type X-Ray system. During standby periods, the tap-switcher periodically failed due to its inability to sense current properly. This design deficiency shorted the output voltage taps. The output short cleared by opening the fuse protecting the SCRs, which created a large transient on the output terminals and damaged the X-Ray system. Although the problem started in the regulator, it appeared as though the fuse went out as the result of a component failure with the X-Ray. So, the X-Ray manufacturer received the initial blame.

Once the nature of the problem was discovered, a clamping TVSS was installed on the regulator output. This eliminated the damage to the X-Ray system, but the tap-switcher still continued to fail once or twice a week. Unable to resolve the current sensing problem, the regulator manufacturer finally decided to disable the regulation during standby. This resulted in no regulation except during exposures. So for 99.5% of the time, a voltage sag could still cause control errors or resets. Because the facility had not been experiencing sags or voltage variations anyway, this arrangement was acceptable to the X-Ray manufacturer. The unfortunate result was that the facility paid $30,000 for a regulator that did little more than a 112kVA transformer. □