# Twin Technologies Test Transformer Reliability

by **Allan Rienstra**

**WE CAN DRAW COMPARISONS BETWEEN THE SYMBIOSES IN FRATERNAL TWINS TO THOSE PREVALENT IN TECHNOLOGIES USED TO MONITOR THE HEALTH OF ELECTRICAL ASSETS. THIS IS ESPECIALLY TRUE OF ULTRASOUND AND INFRARED THERMOGRAPHY; TECHNOLOGIES THAT EXTEND OUR HUMAN ABILITY TO HEAR AND SEE.**


Photo: SDT Ultrasound

Despite being spawned from the same DNA, there is no certainty that fraternal twins will look and behave the same. They might show different eye and hair color, they can have similar but not identical facial features, heights, and of course they can be the same, or opposite gender.

What is often the case, however, is the ways in which their personalities and characteristics complement each other. Some fraternal twins even make claim to having a mental connection — coined 'twin telepathy' — that allows them to share an uncommonly close mental bond with their sibling. Despite the lack of scientific evidence to support the existence of telepathy between twins, case studies demonstrating high levels of collaboration and cooperation are numerous.

We can draw comparisons between the symbioses in fraternal twins to those prevalent in technologies used to monitor the health of electrical assets. This is especially true of ultrasound and infrared thermography; technologies that extend our human ability to hear and see.

Ultrasound is a useful technology that extends the range of human hearing. It empowers inspectors to hear sounds they normally could not. Inspectors can use the information

*The laser of this parabolic dish from SDT is pointing at the left phase of this 36 kV transformer while the inspector remains safely on the other side of the fence.*

**Allan Rienstra** Some say I am passionate about ultrasound. They are not wrong, but not right either. I am passionate about helping people get the most from their investment in technologies that create safe workplaces, reduce unplanned downtime, and eliminate waste. Ultrasound just so happens to be *that* technology. There is so much we can do to create accident free, proactive, environmentally sustainable conditions in manufacturing. All we need to do is *care* and *hear more*. If you care like I do, join me and together let's make Earth Great Again!

gleaned from ultrasonic detectors to identify changes in normal operational parameters of critical assets. Moreover, they can do so in difficult, high-noise environments where the naked ear is useless. Properly trained technicians inspect, detect, measure, trend, and analyze ultrasound data so as to anticipate the need for maintenance intervention very early in the potential failure curve.

Infrared thermography is useful for detecting thermal anomalies not seen by the human eye. By displaying heat radiating from the surface of an object as a visual image, personnel with limited or no infrared experience can see patterns of temperature distribution from an asset. Using infrared in predictive and preventative maintenance is beneficial to electrical asset reliability. By locating potentially harmful abnormalities early, simple maintenance and repairs are carried out before damaging the equipment, or unplanned outages or catastrophic failure occur.

Ultrasound on its own hears many, but not all, symptoms of failure in electrical assets. Likewise, infrared thermography sees defects that produce heat, so long as that heat transmits to the surface of the asset. Inspectors using one of these technologies on its own can hope to tell a substantial story. But when

the two technologies are deployed together, expect a more complete and accurate accounting of the asset's condition.

Many electrical faults are the result of partial discharge which is defined as "a localized electrical discharge in an insulation system that does not completely bridge the electrodes." A discharge is described as either an "arc" or a "spark" and can be phase to phase, or phase to ground. Partial discharge is destructive to the conductor or insulator, and over time, will cause the component to fail. The integrity of insulation material is further damaged by corrosive gases like nitrous oxide. The time it takes for a system component to fail is related to system voltage, the shape of the void from phase to phase, ambient temperature, the condition of the insulation material, and environmental conditions such as pollution and humidity. The higher the voltage, the more destructive the partial discharge becomes.

One stage of partial discharge is termed "tracking." Tracking is difficult to detect since it doesn't produce heat. Like corona discharge and arcing, tracking exists only to seek a path to ground. Dirt, dust and moisture help tracking follow this path, which is why simple maintenance like cleaning is effective in prolonging the service life of electrical systems, Figure 1.

*Figure 1.*
*An electrical service technician applies simple dry ice cleaning on a residential transformer.*

*Figure 2.*
*Tracking has begun to erode the enamel coating on this insulator. Moisture can impregnate and either super heat (arcing) or freeze. The insulative properties are failing and partial discharge will only worsen from here.*

Ultrasonically, tracking begins with a low buzzing and crackling sound and builds in loudness until it reaches the point of flashover. For this brief moment there is heat, thus for an inspector relying solely on infrared, timing is everything. After flashover, tracking quietens and cools. It is this repetitive, persistent build up in intensity and discharge that leads to insulation breakdown, and eventually the progression to more destructive arcing.

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The earlier an electrical fault is detected the less expensive it is to schedule and perform maintenance to mitigate risks. Early detection of an electrical fault can be the difference between a simple dusting and cleaning versus costly overhaul or even total repair/replacement.

Take for example one instance where a condition monitoring inspector, trained in both infrared and ultrasound disciplines, was tasked with inspecting a three-phase transformer in a steel mill. Had he relied on only infrared imaging data, he may have missed symptoms of an underlying issue that was progressing toward catastrophic failure.

Skip Young is a CAT 2 certified infrared thermographer as well as an SDT Level 1 ultrasound inspector. He was tasked to inspect electrical assets for a major steel manufacturer in Calvert City, Kentucky. Processing steel requires heavy duty electrical power systems. A single electrical component failure is all it takes to completely stop production, resulting in the loss of crucial time and money.

This inspector knew that electrical faults only generate heat once they've reached an advanced stage. Relying solely on infrared may have resulted in a missed diagnosis. Whenever conducting thermal scans, Young includes ultrasound as well. He knows that acoustic energy is generated at all stages of discharge and that by combining ultrasound and infrared scans there is less chance of a missed diagnosis.

Figure 2 displays an example of an electrical problem detected in its early stages with ultrasound. The insulator was damaged with tracking which indicates the presence of an equipment fault. When caught at an early stage, it can often be fixed with simple maintenance procedures.

Thermal images from several 161 kV to 13.8 kV step-down transformers were included in Young's report. The infrared image reveals no hot spots on the A phase bushings (Figure 3), but an ultrasound scan produced a sound file with obvious indications of early tracking.

*Medium and high voltage switchgear poses great risk to inspectors. To mitigate the potential of an arc flash or arc blast incident when the panel is opened, ultrasound inspection first confirms the presence of any partial discharge sources.*


*This 6 kV transformer is inspected from the safe side of the fence for partial discharge, tracking, and destructive arcing.*


*Figure 3.*
*Infrared did not discover any electrical anomalies; however, additional ultrasound scans revealed the onset of early stages of corona discharge.*

Photo: SDT Ultrasound

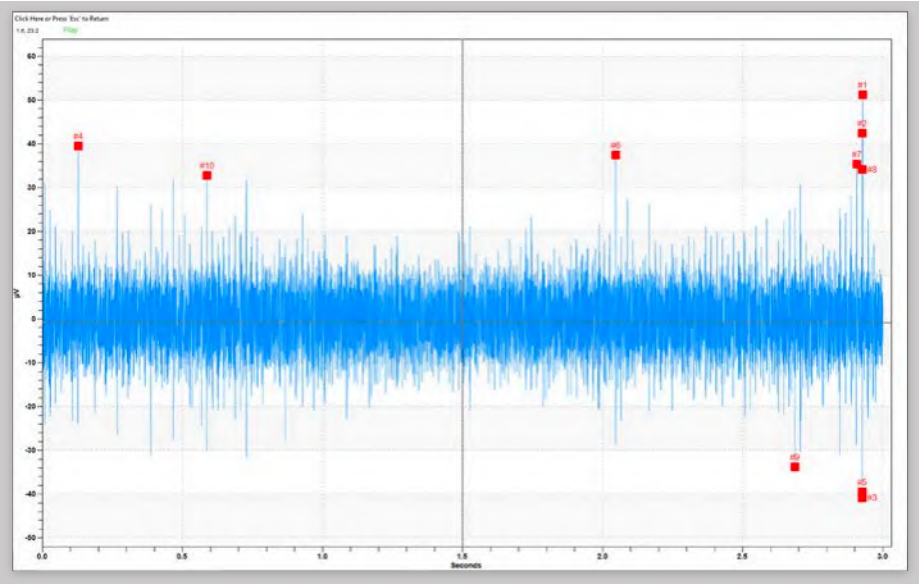


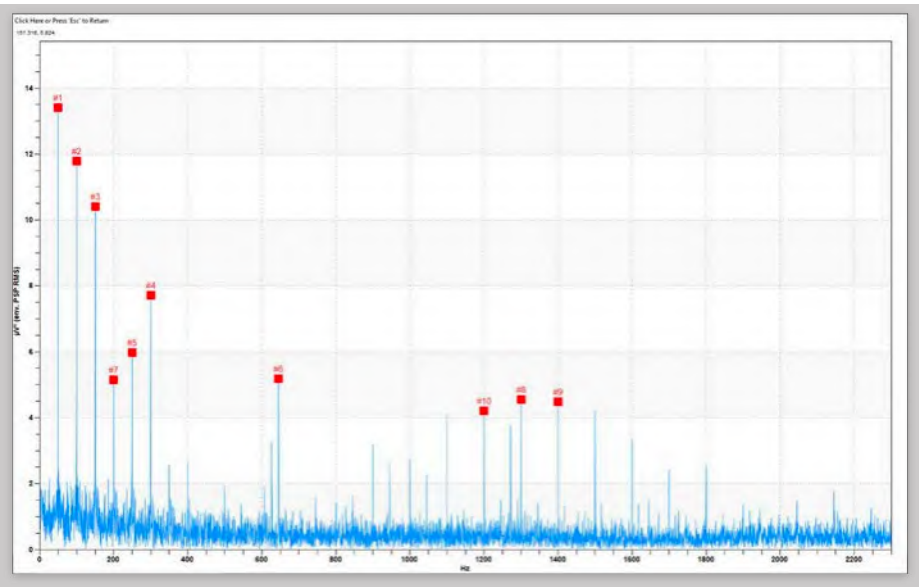
*Figure 4.*
*Time waveform taken with SDT270 shows partial discharge activity classified as nuisance corona. Simple maintenance such as cleaning and tightening is required.*

Figure 4 illustrates the time domain showing the build-up and release of the ionization discharge as it finds a path to ground. Ultrasonically, we hear the build-up and then a neutralization of the air surrounding the problem. Heat does not build up here until the situation progresses and there is sufficient flow or current to produce heat along the discharge path.

Figure 5 illustrates the spectrum domain from Young's ultrasonic data. There are two things to note here. First, the repetition of 60 Hz events in the spectrum clearly reveals the presence of nuisance corona at the line frequency. Secondly, the short, abrupt bursts of energy in the timewave image, without the presence of heat, confirms there is tracking activity.

Similar tracking activity was discovered from the B and C phase bushings, while neither showed any signs of heat when scanned with an infrared camera.

Once the diagnosis was made on the suspect transformers, the decision to perform simple maintenance during the next planned outage was made. Since the problem was discovered at an early stage, the simple maintenance could be done on the terms of the maintenance crew rather than dictated by asset failure. This involved a cleaning and tightening of all connections on A, B, and C phase bushings.



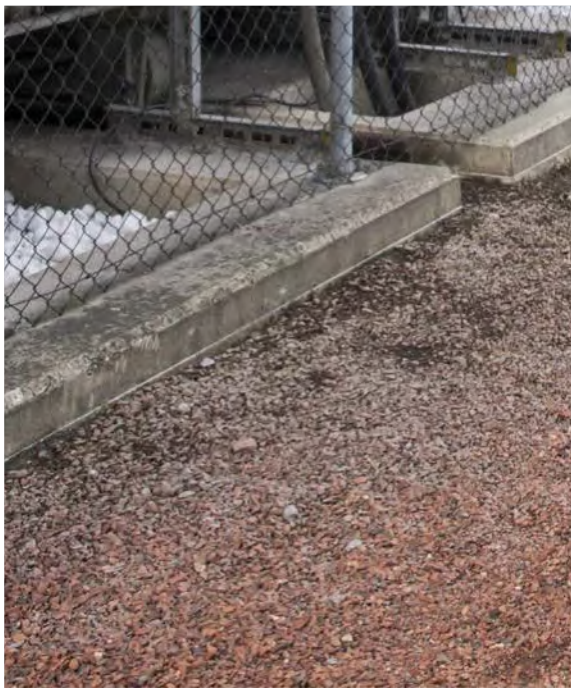


*Figure 5.*
*The frequency view of the same ultrasound signal clearly shows 60 Hz line frequency. This is a classic example of nuisance corona.*

*When measuring the dB level of partial discharge with ultrasound it is important to keep the distance between sensor and asset consistent.*

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Photo: SDT Ultrasound

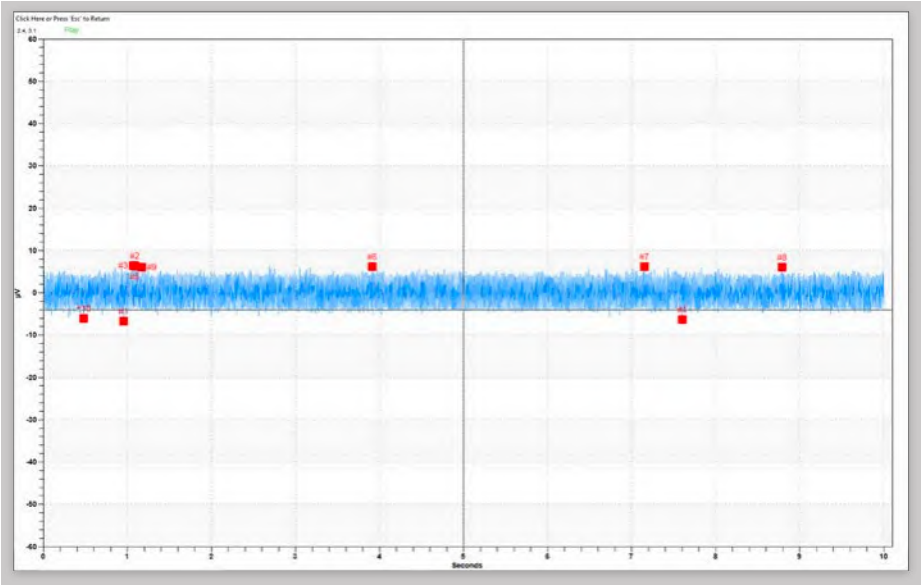
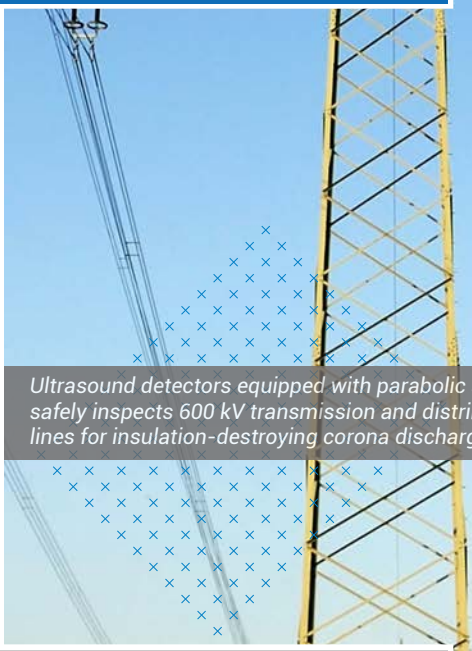


*Figure 6.*
*Time waveform after simple maintenance shows a satisfactory drop in discharge activity.*

Looking at the time signal in Figure 6 and the frequency signal in Figure 7, maintenance definitely improved the condition of the asset. Since tracking is a stage of partial discharge that does cause damage to connectors and insulators, it will be necessary for Young to continue his vigilant ultrasound scans moving forward.

Ultrasound and infrared deployed in tandem performed well on this transformer issue. Moreover, there is no reason why the pairing should not be considered a winner for observing partial discharge on insulators, MCC panels and high voltage transmission and distribution lines.



*Ultrasound detectors equipped with parabolic sensors safely inspects 600 kV transmission and distribution lines for insulation-destroying corona discharge.*

Photo: SDT Ultrasound

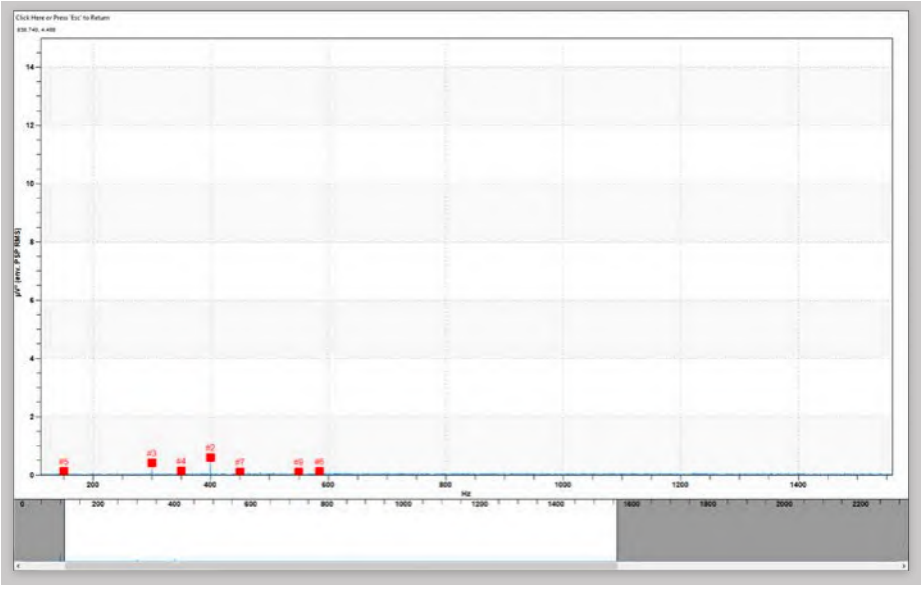


*Figure 7.*
*Spectral view after simple maintenance confirms the system was restored to good working condition.*

There is no single manufacturer that organically developed both ultrasound and infrared. However, through merger and acquisition or inter-company partnerships, these technologies are, in some instances, born of the same 'parent'. Just as fraternal twins are not identical in appearance, but share a common mental link, synergies between ultrasound and infrared technologies allow for a cooperation that can yield tremendous advantages for electrical asset reliability.