Partial Discharges (PD) Acoustic Detection

Introduction

Partial discharges (according to IEC standard 60270) are harmful electrical discharges in electrical systems, the early detection of these anomalies, as well as the identification of the exact location of the emission will help to carry out corrective actions on time and high efficiency. These discharges release energy from time to time, creating a distinctive acoustic signature that can be captured by an ultrasound listening device (ULD).

According to current statistics, 85% of power failures occur in medium and high voltage transformers, as well as partial discharges such as the corona effect are the main causes of power loss and damage to electrical equipment insulation, hence the need to have an inspection tool for these discharges at hand, and more so in acoustic inspection where most of the time there is no temperature increase in corona discharges.

Partial Discharge – Corona

Corona discharge is the luminescent or electrical discharge around conductors when the surrounding air is stressed beyond its point of ionization without developing disruptive discharges. Corona looks for a path to land through the air. Furthermore, high energy discharges can cause mechanical, electrical and thermal damage.

Corona is a changing zone of ionized gases, identifiable to the inspector through airborne ultrasound. Corona discharge occurs when the voltage in electrical conductors, such as an antenna or a high-voltage transmission line, exceeds the threshold value. The air around the high transmission line begins to ionize to form a blue or purple glow, generally visible in total darkness and with high humidity in the environment.

Corona itself is not always a sign of impending failure, however it is an opportunity to investigate the consequences of the crown to determine if corrective action should take place. Corona, however, can be catastrophic. It can cause the loss of expensive power management components.

The ultrasonic signature of the Corona Effect is very characteristic, this is a buzz type background sound, with blows on it that are equivalent to the individual discharges, these blows as seen in the waveform graph at the top of figure 1, They are very constant in time series and are on the same frequency as electric power, 50 Hz or 60 Hz depending on the country where they are taken. By having broad redundancy of the discharges, they generate a spectrum full of harmonics, shown in the frequency spectrum (FFT) of figure 1.

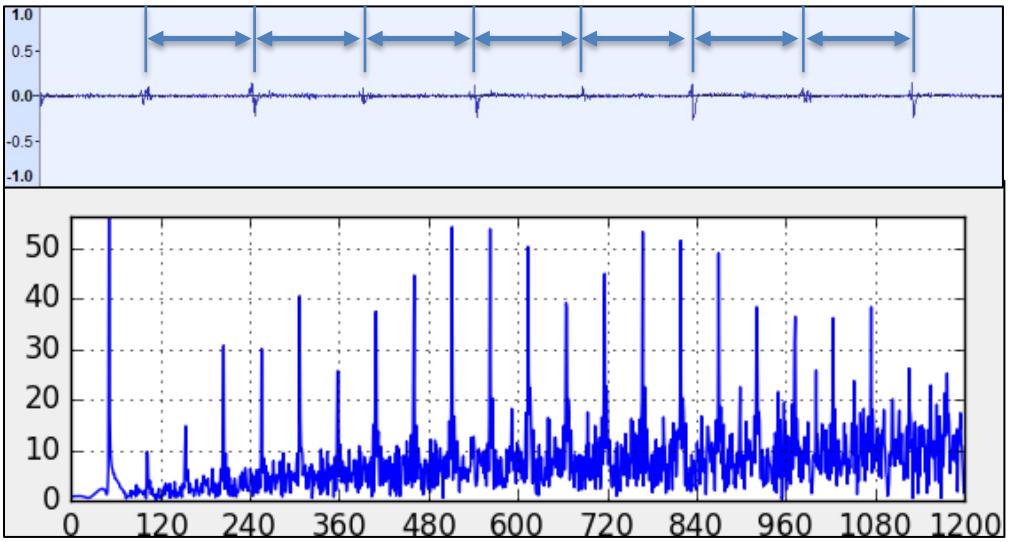
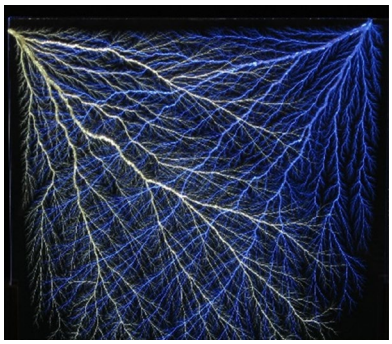


Fig. 1: Ultrasonic signature of Corona Discharge.

Corona discharges are important because they guide us to possible problems with the main supply in medium and high voltage, maintaining our assets properly will help us not to lose energy at unexpected times.

Partial Discharge – Tracking (or Electrical Treeing)

Tracking discharge is an initial stage of the Electric Arc, it follows a path over the damaged insulation looking for ground. This charred path will lead to reduced insulation and the ability to leak current from the conductor. Very often no heat is generated, but as the condition becomes more intense, a temperature rise will be produced that can be detected by an infrared camera. This discharge requires serious attention, as the problem is imminent.



Tracking creates a carbonized current leak path in the form of lightning-like fractals, these over the dielectric that lost its capacity and are prematurely damaged by the discharge. This form is also known as Lichtenberg Figures in honor of the German physicist, Georg Christoph Lichtenberg. This tree structure is associated with the progressive deterioration of components and equipment under voltage, which the higher the voltage, the more problematic and risky a possible event is.

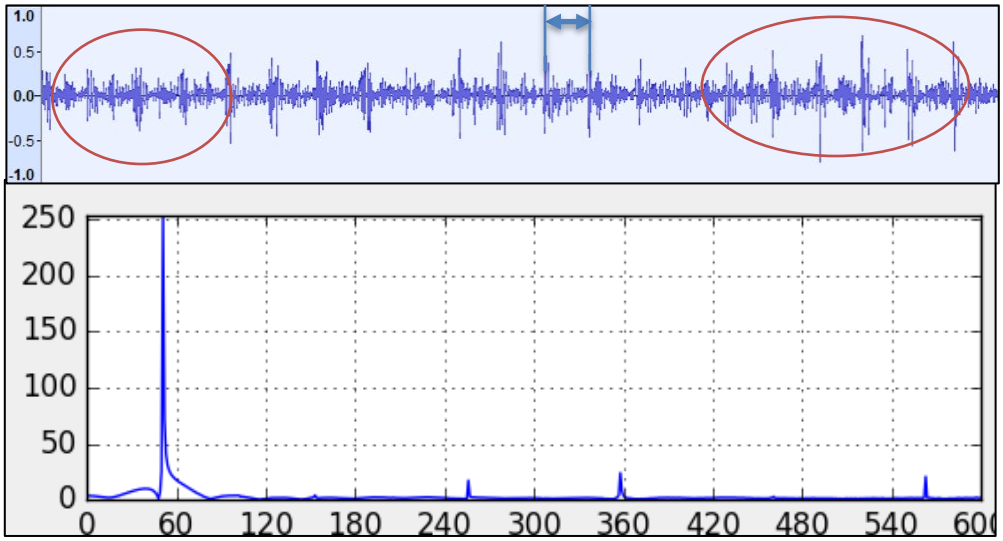


Fig. 2: Ultrasonic signature of the Tracking Discharge.

The monitoring pattern is erratic as seen in figure 2, since the discharges occur irregularly in the waveform of the electric current, that is, each shock of discharge has a component in the frequency of the electrical energy, however, it is very active as can be seen in the red circles. This can be seen in the decrease in harmonic peaks in the frequency spectrum (FFT), where there are peaks in 50 Hz or 60 Hz (depending on the electrical frequency of each country), but these are hidden since the behavior of the signal is irregular.

Partial Discharge – Electric Arc

The electric arc means a passage of current that can manifest as discharges, these are a more advanced step of monitoring, where the discharges occur in amounts where they can no longer be treated individually, rather, as bursts of energy. In high voltage systems the arc length can be considerably longer, before the system impedance tries to regulate or limit the fault current.

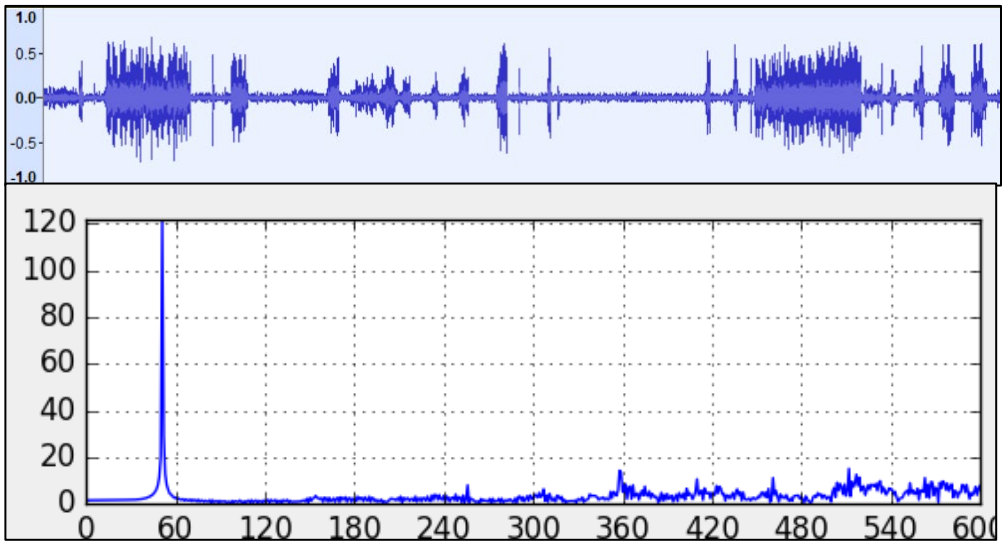


Fig. 3: Ultrasonic signature of the Electric Arc Discharge.

In figure 3 we can see the great difference between small discharges against energy blocks that are equivalent to the discharge of the electric arc, when we find an electric arc we are facing a security risk and an imminent failure, immediately action must be taken to prevent further damage.

Versatility of Use of Acoustic Ultrasound

Taking into account the ability to hear these discharges in the air, and making it clear that we can check insulators in medium and high voltage lines efficiently, we must also highlight the common uses of acoustic ultrasound in electrical inspections.

Inspection of Closed and Underground Systems

Ultrasound is a great tool to locate problems in closed and underground systems, since the acoustic emission guides us to the exact areas of interest and we can listen to them despite not having an angle to see them with an infrared camera, which makes the tool very useful for the inspector of these systems.

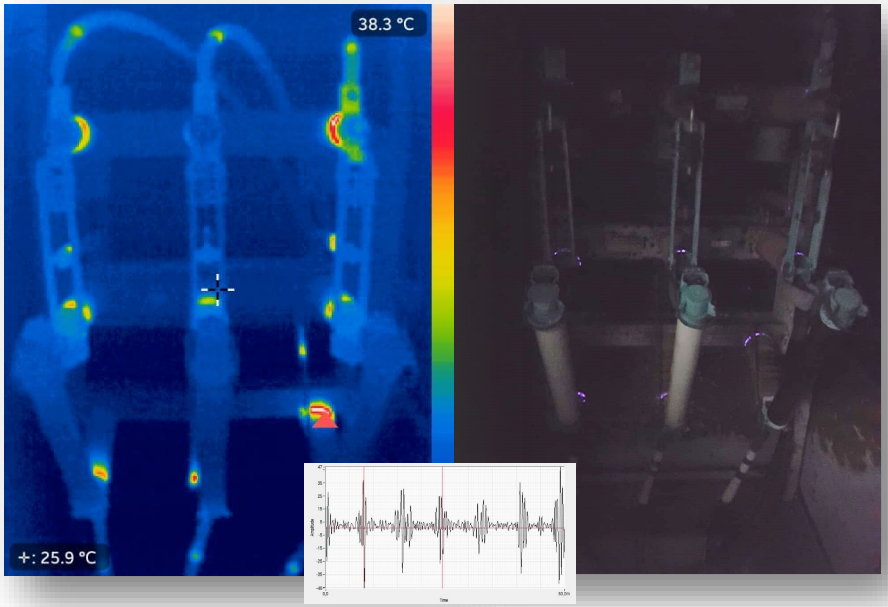


Fig. 4: Inspection of Medium Voltage Cell by Acoustic Ultrasound and IR Camera.

The separate ultrasound helps plant personnel to follow the protocol for opening cabinets and closed electrical panels, since they can listen behind a door to any abnormal situation that can help us make decisions that affect the safety of inspectors, such as not opening a door with a potential problem behind it. In figure 4 we can see that an anomaly was detected with ultrasound without the need to open the cell door. To see it with thermography, an IR peephole or fireproof suit should be used.

Concusiones

The inspection of Partial Discharges (PD) in electrical components is based on the fact that these discharges emit high-frequency sounds, which are highly directional, which allows the instrument to locate the emission source with ease, allowing appropriate actions to be taken to care for the assets that are being monitored.

However, acoustic inspection also has its limitations, mainly given by areas with a lot of ultrasound in competition (other emission sources close to the area of interest), apart from

the sensitivity of some equipment, it is not adequate to inspect safely and accurately. In addition to having to purchase expensive equipment to fulfill the right task.

CTRL Systems has specific equipment for electrical inspection, the "Electrical Inspector" Kit and the "Corona Detector" Kit have everything necessary to find and locate Partial Discharges in electrical components, locate and report. Apart from being the device with the best SNR (Signal-to-Noise ratio), which makes it the team with the highest sensitivity to locate these problems.

The UL101 Kit was selected for its best SNR quality, ease of use, compact design and cost benefit by technical teams from large entities such as NASA (there are 2 devices on the ISS detecting leaks in space), Boeing (the device is part of the Aircraft Manual of Maintenance on Ground), and most of the electric power generation, transmission and distribution companies in China, India, United States, Mexico, Colombia, Cambodia, among others.