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NEW POSSIBILITIES IN DIAGNOSTICS OF HIGH-VOLTAGE ELECTRIC MOTORS

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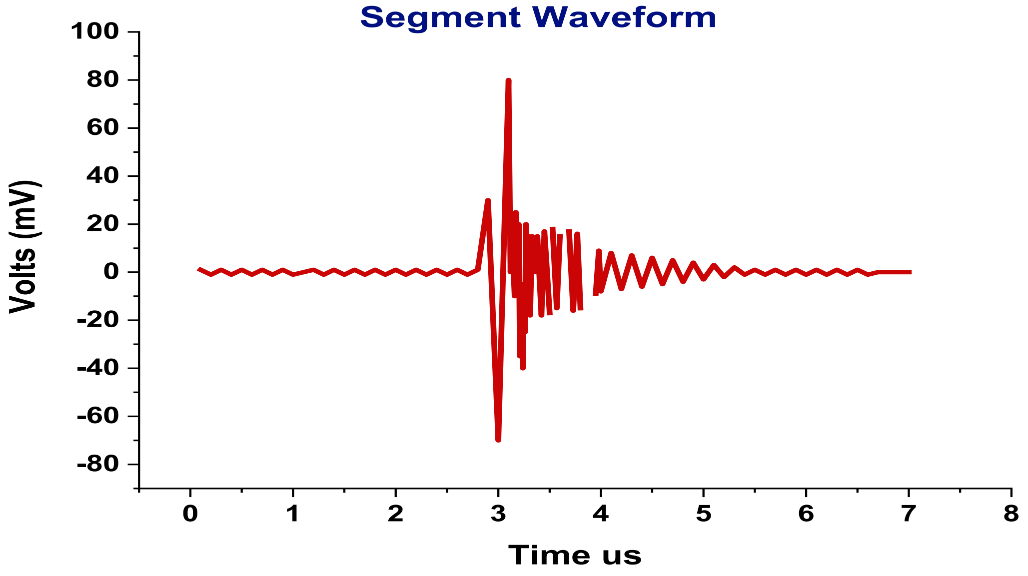
A comprehensive review of the current knowledge of methods for early diagnosis of problems in the stators of high voltage electric motors is presented. Various destructive methods have been applied and the possibility of using an innovative non-destructive method for the determination of partial discharges in high-voltage motors. It was revealed that the deterioration of the state of the stator winding insulation can be due to electrical, thermal, mechanical and natural causes. It was found that numerous noises and signals not related to partial discharges occurred at the time of data recording, which made it difficult to detect partial discharges automatically by the device itself.

This article presents a comprehensive overview of current knowledge on methods for early diagnosis of problems in the stators of high voltage electrical machines, as well as various destructive methods and the possibility of using an innovative non-destructive method for detecting partial discharges in high voltage motors.

When analyzing the results in mV, you can get information about the shape of the discharge signal decomposed on the Fast Fourier Transform (FFT), which allows you to find out its amplitude, frequency and repeatability [8]. The pulse signals generated by PD activity tend to repeat and increase over time, which also allows the detection of discharges when analyzing their characteristics. Decomposition of the signal using the FFT (Fig. 1) allows personnel to manually separate PD signals from noise, which can greatly affect the results of the received signal, and the nature of external noise can be almost any, up to impulses caused by PD activity in equipment that is either connected to car or is nearby (much more common in generators) [7].

When decomposing the PD signal using the FFT (lower graph), it can be seen that in a pulse with a duration of 1.13 µs, several frequencies dominate at once, many of which are not related to partial discharges. To correctly identify a PD signal, it is necessary to trace its repeatability, frequency, and waveform. In this case, the peak of the PD signal has a frequency of 36 MHz, however, it can be seen that the graph is dominated by frequencies of 10 MHz and 4 MHz, which do not belong to the PD and are a consequence of external interference and noise. This can be checked by comparing the readings from the Rogowski coil with the readings of the transient voltage (TEV) sensor mounted on the machine's cable entry housing and designed to measure external signals.



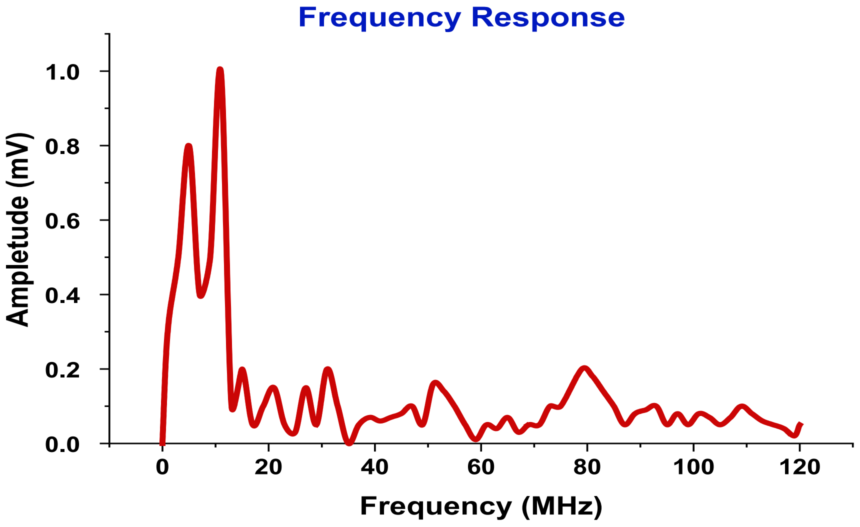
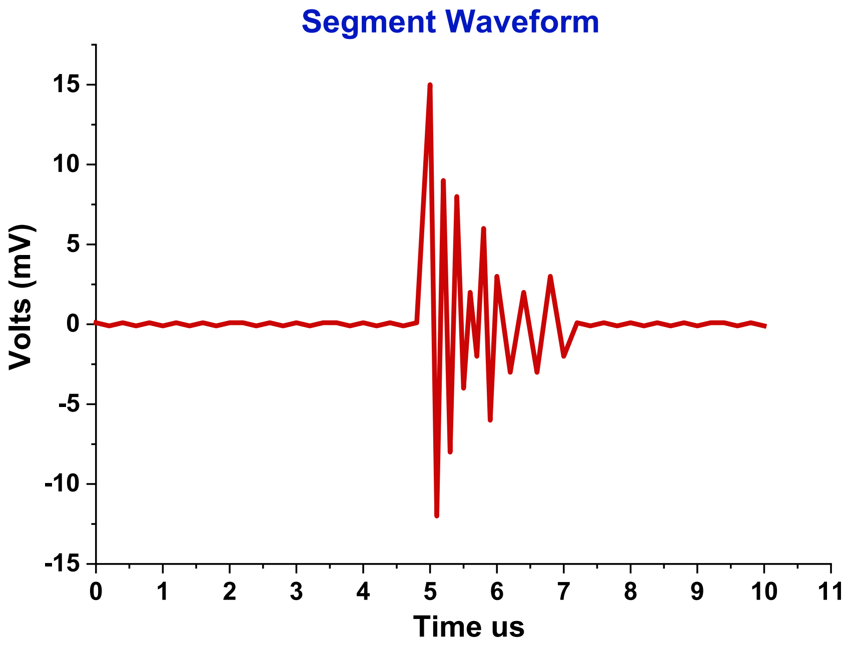


Figure 1. **Decomposition of the trend of the PD signal of the motor phase into an FFT [7].**

The discussion of the results. The analysis of the obtained results in this case is carried out only using PRPD due to the fact that it was not possible to calibrate the measuring setup, which required a short-term shutdown of the motor. PRPD (Phase Resolution Partial Discharge) is a graphical visualization that describes the path, frequency, and phase relationship of PD signals over a period of time in a 2D or 3D representation of the signal. These templates are cumulative PD information which may also include information about the source type of PD intensity acquired over a certain period of time. Extensive studies to introduce these models corresponding to different types of PD sources have been carried out.The signal trend in mV was used only to determine the frequency of the signal and its repeatability (Fig. 2) [9].

Figure 2 shows that the discharge pulse has a frequency of 17.5 MHz with a tendency of systematic repetition, which can be considered a partial discharge. It is worth mentioning that the meter also marks this signal as PD.



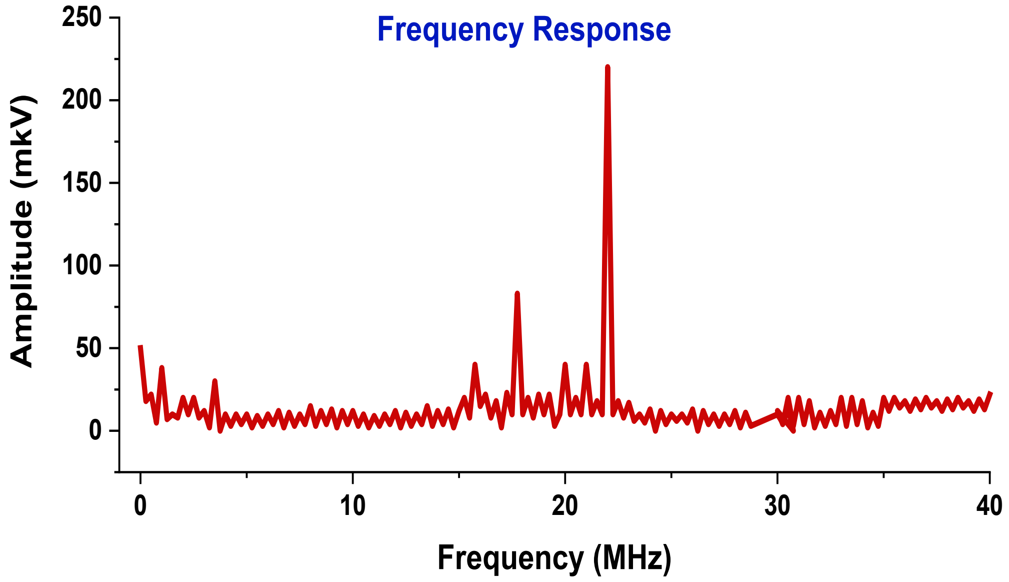


Figure 2. PD trend of one motor phase on FFT [7].

Figures 3 show the "PRPD" graphs. It is worth mentioning that for the accuracy of the experimental data, the results were obtained from two instruments under the same measurement conditions.
This case corresponds to the presence of delamination between the conductor and the insulation as specified in IEC 60034-27-2 A.3.2.3. The charts were obtained on the HVPD Longshot (Figure 3)

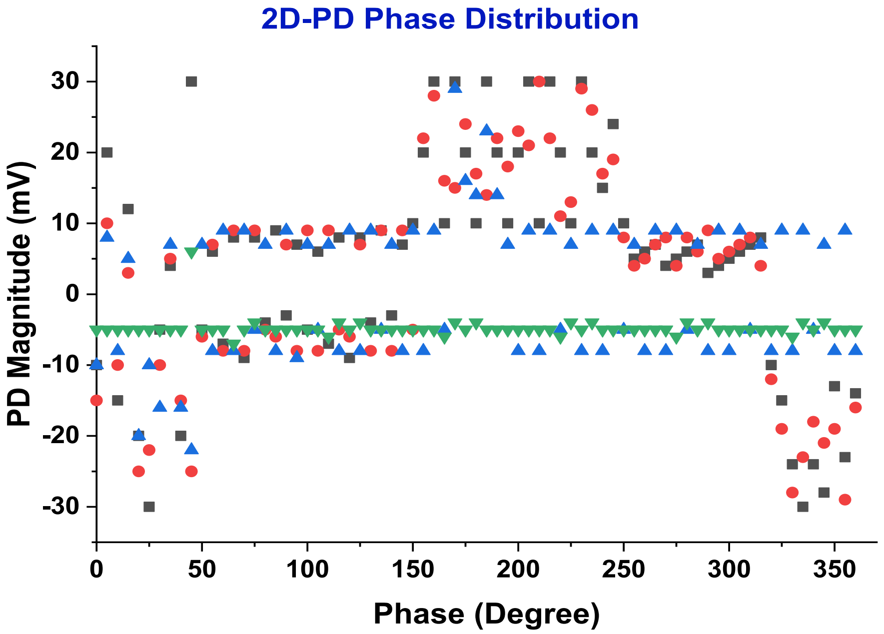


Figure 3. Graphs obtained on the installations "HVPD Longshot" [9].

CONCLUSIONS

The amplitude of the measured PD trends can be used to measure the magnitude of the discharge in pC only if the measuring setup has been pre-calibrated; in the absence of calibration, the discharge trend can only be used to measure the frequency. Whereas the waveform obtained on the PRPD plot remains unchanged even in the absence of calibration. This indicates that the nature of the occurrence of a PD can be determined with high efficiency and accuracy and without calibration, but the magnitude of this charge is not.

It was revealed that the deterioration of the state of the stator winding insulation can be due to electrical, thermal, mechanical and natural causes. It was also found that numerous non-PD noises and signals occurred at the time of data recording, making it difficult to detect PD automatically by the instrument itself. However, after a long review of all records manually, without the help of the device system, the noises were identified and eliminated.