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Partial Discharge Detection using PDS 100

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***Abstract* - Partial Discharges in power equipment may be a symptom of a fault in a component and in such cases their detection at an early stage is essential. This paper presents the detection and identification methods based on frequency and time domain measurements made with an antenna, oscilloscope and a laptop. The purpose of this research was to quantify the RF/IEC relationship under controlled laboratory conditions using well defined test samples. The identification of different HV equipment discharge by radio frequency interference measurements with the help of DOBLE instrument PDS100 was studied at a High voltage laboratory.**

***Index Terms* - Partial discharge, radio frequency measurement, frequency domain, time domain, detection of PD signal**

I. INTRODUCTION

Partial discharges (PD) are small discharges caused by strong and inhomogeneous electrical fields. The reason for such fields could, for example, be voids, bubbles or defects in an insulation material. Detection of PD is performed in order to ascertain the condition of the insulating material in high voltage elements, e.g. Generators, transformers, gas isolated substations, cables, etc. Since PD usually occurs before complete breakdown, PD monitoring provides a warning to remove the power system element from service before catastrophic failure occurs.

II. RF MEASUREMENT

The current at the PD site has a rise time in the order of nanoseconds and due to rapid acceleration of charge, gives rise to electromagnetic wave with energy spectra extending to frequencies of 200 MHz and above conveniently, high the voltage plant inside which partialdischarge often occurs are in the form of a closed metallic chamber for example a GIS chamber or a transformer. These chambers will be excited intovarious modes of resonance which, along with their low loss will allow the RF signal to persist for up to 1 µs.Because RF signals radiating from the PD site are not greatly attenuated by electrical insulation any signal measured by an RF sensor will contain multiple reflections of the same pulse along with frequency components corresponding to the resonant modes of the GIS chamber or transformers. This gives the advantage of high sensitivity and good signal-to-noise ratio but interpretation of the signal is often difficult.

A useful analogy here is that of ringing bell, the RF signal can be likened to the acoustic ringing of the bell once stuck, with the original PD pulse analogous to the hammer providing the initial mechanical excitation.Although the electromagnetic effects of PD have long been known, it was not until the early 1980s that significant effort was focused toward developing field operable discharge location systems based on the electromagnetic means of discharge detection and location. The need for such system arose due to relatively high failure rate of GIS at the time and the deficiencies of the acoustic location method.

Since the RF method is a relatively recent technique, it has not yet gained worldwide acceptance of its ability to quantify PD magnitude. This is because the technique responds to the rate of change of the PD current pulse rather than its integral and it is therefore not possible to quantify the PD magnitude in terms of pC.

III. GENERAL ACCEPTANCE OF RF TECHNIQUE

An important aspect of this work regards contributing to the general acceptance of the RF technique as a diagnostic tool. Although it is not a true quantification of discharge severity, the pC level is the generally accepted measured among manufactures and utilities used to judge the condition of an insulation system. It is impossible to quantify the pC level using RF technique alone. This is because the fundamental principles behind the IEC and RF technique are; RF measured resound to the rate of change of current, whereas IEC measurement attempt to quantify charge. This is the fundamental reason why calibration issues are considered to be difficult to establish. However, if RF signals are measured along with a corresponding calibrated apparent charge IEC60270 systemthe correlation plots may provide useful information.

IV. TRADITIONAL METHODS

Traditionally, PD tests have been performed on a periodic basis, approximately every 6 to 12 months. However, most standards related to the online assessment of insulation systems recommend trending of data in order to provide the best assessment. Setting alarms or basing judgments on PD pulse magnitudes (Q_m) alone are not sufficient. Some of these methods are Chemical Detection, Acoustics detection and Electrical detection.

No standard exists that clearly defines what magnitudeofPD activity is considered "good" or "bad". Somesuppliers of PD technology have published data in an attempt to get to this point, but the data is conflicting,and thus controversial methods are very complicated to use because

- Lack of calibration. - No calibration of the system has been performed. Many less than ideal installations of coupling capacitors at the line terminals of motors and generators have been observed. The high frequency signals produced by a PD event attenuate quickly as the traveling wave moves through a winding. In order for the PD signal to properly propagate, a low inductive circuit is required. Unless calibration has been performed on each and every machine, comparison of absolute values of Q_m is not valid.
- In many cases, a pulse count is much more important than magnitude. In order to choose the proper parameters to monitor, we recommended following any of the key standards related to making PD measurements found within IEEE and IEC. We also recommend that PD power or PD Intensity be the key factor to monitor since they take into account both magnitude and pulse count.
- Trending is the key factor in determining the condition of an insulation system. A low level of PD increasing quickly will signify a major defect, while a high level of PD that is stable indicates there is a major defect, but it is not getting worse. A generally accepted "rule of thumb" in the PD industry is that a doubling of PD levels in six months will indicate the insulation is in poor condition and is quickly deteriorating.

There are several external factors that may significantly affect partial discharge. The most important are voltage, temperature, humidity or absolute moisture in the air or insulating fluid, load current and hydrogen pressure. Neglecting these factors may produce incorrect diagnostic conclusions resulting in missing a problem or producing a false alarm. In addition, correlating PD characteristics to these factors frequently provides valuable information that allows one to further discriminate the type of PD failure mechanism and to plan more appropriate corrective action.

V. IEC Standard 60270

This is standard for High-voltage test techniques – Partial discharge measurements. Where pulses of a known chargeare injected into the object under test has meant that an upper limit on PD activity can be quantified in terms of Apparent Charge. The exact mechanisms and resulting signal properties of a partial discharge are not completely understood, though there are guidelines used by engineers when designing partial discharge detection systems. One such standard is the IEC60270 which details test techniques for measuring the apparent charge of a PD pulse. It provides definitions and descriptions relating to measurement circuits and methods as well as calibration and test procedures for instrumentation. The main strength of the IEC60270 standard relates to experience gained in its application. This has resulted in a test specification which is internationally accepted. An accepted standard for calibration of IEC60270 instruments, where pulses of a known charge are injected into the object under test, has meant that an upper limit on PD activity can be quantified in terms of apparent charge. Additionally, the conventional system is relatively simple to implement, since sensors can be fitted non-intrusively.

VI. Introduction To The PDS100

The PDS100 Partial Discharge Surveyor is a handheld, battery-powered instrument that detects radio frequency interference (RFI) from the partial discharge (PD) that is emitted by most substation components with faulty or degraded insulation.

The instrument uses radio frequency scanning, a non-intrusive, in-service test that measures the electromagnetic signals produced by partial discharges. The PDS100 can be operated in any power station thatprovides a direct view of all high-voltage apparatus. Because discharges can propagate from HV bushings, the instrument can detect PD from transformers and other metal-clad apparatus.

Before we start for surveying a substation some point keep in mind for accurate baseline measurement and eliminate external RFI sources. Consider setting the instrument down on the ground and walking away from it. This ensures that your own movements don't generate PD during the testing. It many sweeps are necessary to accumulate enough data for reliable measurements.

VII. Measurement Technique

The instrument used (Doble PDS 100)have two different detection modes:

1. Spectrum analyzer mode
2. Time resolved mode.

But before get into detail of detection mode we calculate available frequency in environment called as baseline frequency which can includes any available frequency in free atmosphere. It may be FM frequency, TV signals and GSM frequency as shown in below figure. Small band frequency having very high attenuation simply called as energy therefore noise interruptions more and shows very high amplitude on other hand wide band frequency losses it energy as wave propagates distance also noise interruption is less as a result it has less amplitude. Therefore it doesn't mean that small amplitude of frequency is not harmful. The classification of frequency reedited from HV equipment into Corona discharge (0-200MHz), surface discharge (200-450MHz) and partial discharge (above 450MHz)

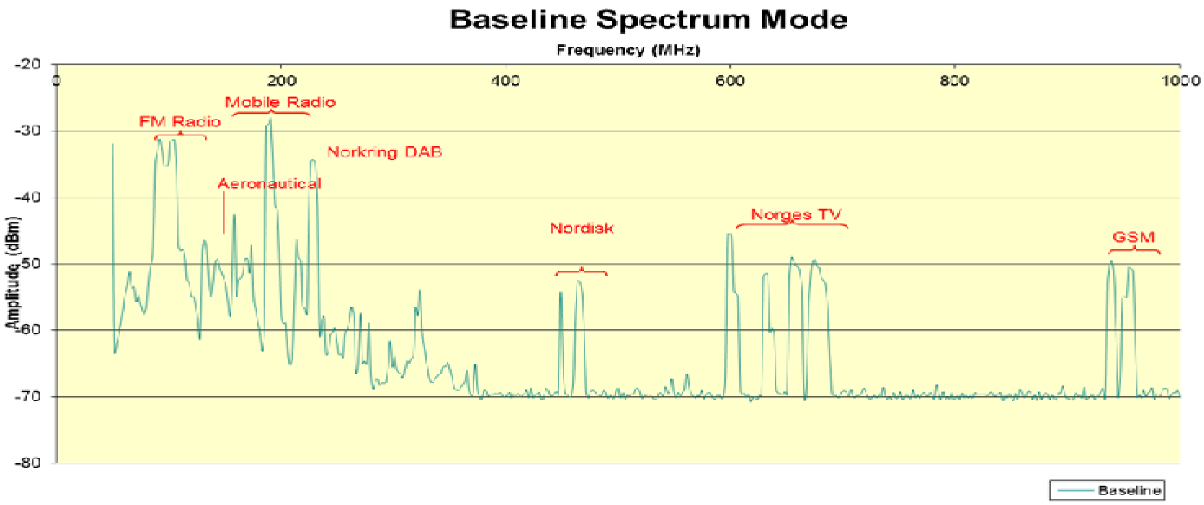

Fig 1 Normal frequency range used for various application taken as baseline

When we take baseline reading compare it with the PD pulse if it shows uplift at any frequency then separate all peaks from total waveform and convert it in to time domain analysis because PD presence in the equipment shows positive amplitude as well as negative amplitude in time domain.

Spectrum analyzer mode

Spectrum analyzer or frequency mode scans the frequencies detecting RFI signals, looking for PD activity. The area of interest is between 50 MHz and 1000 MHz. It is commonly known that the PD activity will be in this frequency range.

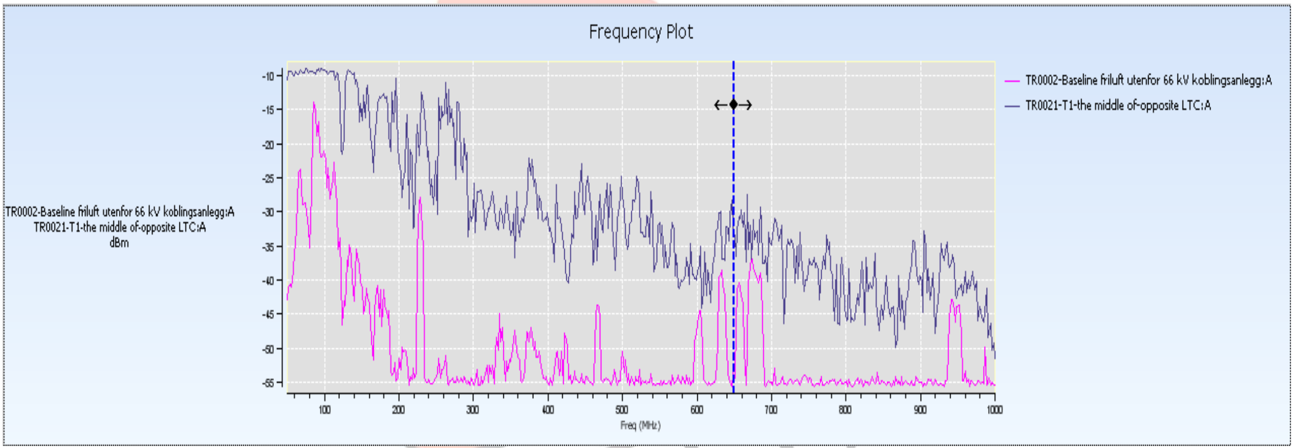

Fig 2 Comparison of measured waveform with baselinetaken away from equipment

Further to the capture of RFI signals, the instrument has a gating time of 40 ms, i.e. the instrument "looks" at two cycles before it moves on and "looks" at the next frequency window. By detecting the peak amplitude of the RFI signal, an RFI emission due to PD activity will be detected and presented. Suppose we select peak frequency at 650MHz shown as vertical dotted line.

Time resolved mode

After detection of an RFI signal shown as a possible PD activity, the given frequency can be set, and the time resolved mode will show the possible PD signal in a time plot, correlated to the power signal, in a time of 20 ms. A typical PD source will emit a pulse twice the power frequency, therefore the shown signal will have a time resolved plot. A smaller PD source might emit a signal only once in the power frequency, i.e. repeat itself every 20 ms. This implies that there will be one or two clusters of peak signals in this mode when there is PD activity present, dependent on the physical characterization of the PD source and the degradation of insulation. Consider time resolved mode contain two part from middle of total display containing first part as positive half cycle and another part as negative half cycle so we conclude PD is present at that equipment.

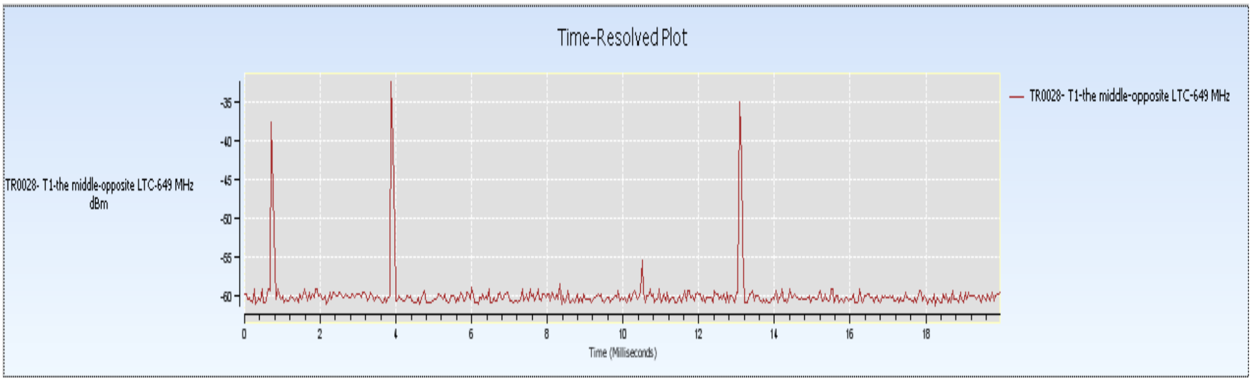

Fig 3 Conversion of highest peak in PD range into time-domain analysis

VIII. Characteristics & Detection Of RFI Emissions

RFI from PD is an intermittent activity of low energy pulses that can be detected over a wide range of frequencies. the attenuation of the RFI originating from the pd is proportional to the frequency and distance of the source of the PD, if a pd signature contains high-frequency components, the source is likely to be strong or in close proximity.

While ordinary telemetry is characterized by a continuous signal withpolarization or direction, RFI from PD is stochastic and intermittent. Telemetric signals have a significant average value that enables them to carry information. In contrast, PD is triggered by high voltage and RFI signals are emitted as sharp pulses with high peaks and low average. The partial discharge accelerates charges (q) in the conductor and this conductor, which is close to the PD location, becomes the transmitting antenna. The timing and location of the peak pulse are determined by the type of insulation flaw and inception voltage.

IX. Conclusion

RFI technique provides an on-site in-service testing without disturbing any live equipment. RFI monitoring offers a routine non-invasive and cost-effective surveillance technique and can assist in the recognition and reporting of PD. Therefore earlier founding PD source can avoid unplanned outages, interruptions, inevitable loss of revenue and penalties of not delivered energy. In this area PDS100 instrument as a first front line RFI monitoring surveyor having great benefit of combining the assessment of RFI emissions with complementary non-invasive electromagnetic interference (EMI) detection technique using the same RFI instrument PDS100.

X. ACKNOWLEDGMENT

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