ADVANCED ONLINE PD MONITORING OF POWER TRANSFORMER AS A TOOL FOR RELIABILITY IMPROVEMENT

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ABSTRACT

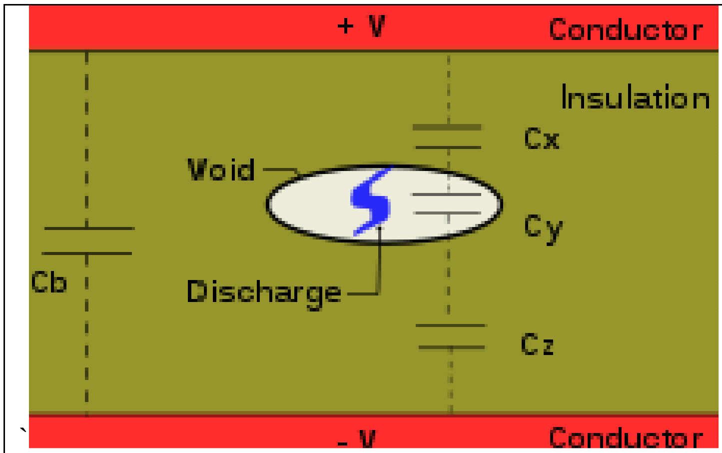
This paper deals with digital acquisition, classification and analysis of the stochastic features of random pulse signals generated by partial discharge (PD) phenomena. In order to promote a better understanding, the first part of contribution attempts to provide simplified explanation for partial discharge mechanism & its principle. The second part of this contribution has made its focus is made on a new measuring system for the digital acquisition of PD-pulse signals, which operates at a sampling rate high enough to avoid the frequency aliasing, but that provides an amount of PD pulses which enables PD stochastic analysis. A separation and classification method, based on a fuzzy classifier, is developed for the analysis of the acquired PD-pulse shape signals. The result of the fuzzy classification is a cluster of signals homogeneous in terms of stochastic features of PD pulses. The classification efficiency is evaluated resorting to the PD-pulse height and phase distributions analysis. The instrumentation, and the associated classification methodology, are applied to measure and analyze PD data recorded for mica-insulated stator bars and coils, where typical defects, occurring during normal operations, were simulated. It is shown that the proposed procedure enables PD-source identification to solve the identification problems which arise, in particular, when different sources of PD are simultaneously active. In addition fuzzy classification provides an efficient noise-rejection tool.

WHAT IS PARTIAL DISCHARGE?

In electrical engineering, **partial discharge** (PD) is a localised dielectric breakdown of a small portion of a solid or fluid electrical insulation system under high voltage stress, which does not bridge the space between two conductors. While a corona discharge is usually revealed by a relatively steady glow or brush discharge in air, partial discharges within solid insulation system are not visible.PD can occur in a gaseous, liquid or solid insulating medium. It often starts within gas voids, such as voids in solid epoxy insulation or bubbles in transformer oil. Protracted partial discharge can erode solid insulation and eventually lead to breakdown of insulation.

DISCHARGE MECHANISM

PD usually begins within voids, cracks, or inclusions within a solid dielectric, at conductor-dielectric interfaces within solid or liquid dielectrics, or in bubbles within liquid dielectrics. Since discharges are limited to only a portion of the insulation, the discharges only partially bridge the distance between electrodes. PD can also occur along the boundary between different insulating materials.



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A partial discharge within solid insulation. When a spark jumps the gap within the gas-filled void, a small current flows in the conductors, attenuated by the voltage divider network Cx, Cy, Cz in parallel with the bulk capacitance Cb

Partial discharges within an insulating material are usually initiated within gas-filled voids within the dielectric. Because the dielectric constant of the void is considerably less than the surrounding dielectric, the electric field across the void is significantly higher than across an equivalent distance of dielectric. If the voltage stress across the void is increased above the corona inception voltage (CIV) for the gas within the void, then PD activity will start within the void.

PD can also occur along the surface of solid insulating materials if the surface tangential electric field is high enough to cause a breakdown along the insulator surface. This phenomenon commonly manifests itself on overhead line insulators, particularly on contaminated insulators during days of high humidity. Overhead line insulators use air as their insulation medium.

PARTIAL DISCHARGE EQUIVALENT CIRCUIT

The equivalent circuit of a dielectric incorporating a cavity can be modeled as a capacitive voltage divider in parallel with another capacitor. The upper capacitor of the divider represents the parallel combination of the capacitances in series with the void and the lower capacitor represents the capacitance of the void. The parallel capacitor represents the remaining unvoided capacitance of the sample.

PARTIAL DISCHARGE CURRENT

When partial discharge is initiated, high frequency transient current pulses will appear and persist for nano-seconds to a micro-second, then disappear and reappear repeatedly. PD currents are difficult to measure because of their small magnitude and short duration. The event may be detected as a very small change in the current drawn by the sample under test. One method of measuring these currents is to put a small current-measuring resistor in series with the sample and then view the generated voltage on an oscilloscope via a matched coaxial cable. When PD occurs, electromagnetic waves propagate away from the discharge site in all directions. Detection of the high-frequency pulses can identify the existence and location of partial discharge.

DISCHARGE DETECTION & MEASURING SYSTEM

The partial discharge measurement, the dielectric condition of high voltage equipment can be evaluated, and treeing in the insulation can be detected.Whilst tan delta measurement allows detection of water trees, partial discharge measurement is suitable for detection and location of electrical trees.Data collected during the procedure is compared to measurement values of the same cable gathered during the acceptance-test.

A partial discharge measurement system basically consists of:

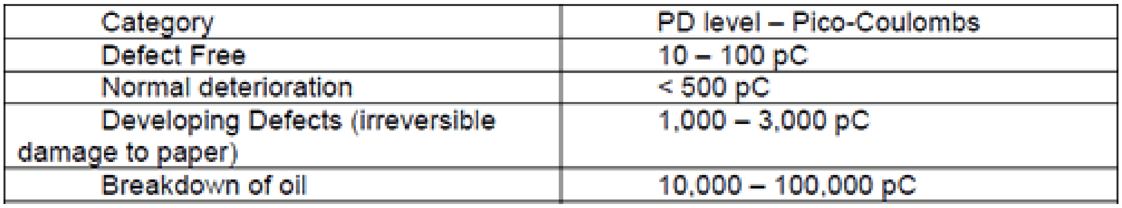
- a test object
- a coupling capacitor of low inductance design
- a high-voltage supply with low background noise
- high-voltage connections
- a high voltage filter to reduce background noise from the power supply
- a partial discharge detector
- PC software for analysis

THE PRINCIPLE OF PARTIAL DISCHARGE MEASUREMENT

A number of discharge detection schemes and partial discharge measurement methods have been invented since the importance of PD was realised early in the last century. Partial discharge currents tend to be of short duration and have rise times on the order of nanoseconds. On an oscilloscope, the discharges look like randomly occurring 'spikes' or pulses. The usual way of quantifying partial discharge magnitude is in picocoulombs. The intensity of partial discharge is displayed versus time.An automatic analysis of the reflectograms collected during the partial discharge measurement – using a method referred to as time domain reflectometry TDR – allows the location of insulation irregularities. They are displayed in a partial discharge mapping format.A phase-related depiction of the partial discharges provides additional information, useful for the evaluation of the device under test.

PARTIALDISCHARGE

Failures of any of the dielectrics inside of a transformer may be preceded by partial discharge (PD). An increase in PD activity or an increase in the rate of the increase should be cause of concern. Since partial discharge can deteriorate into complete breakdown, it is desirable to monitor this parameter on-line. PD sources most commonly encountered are related to moisture in the insulation, tracking on paper and barriers, cavities in solid insulation, metallic particles, and gas bubbles generated due to some fault condition. Partial discharges in oil will produce hydrogen which is dissolved in the oil. However, the dissolved hydrogen may or may not be detected, depending on the location of the PD source and the time necessary for the oil to carry or transport the dissolved hydrogen to the location of the sensor. Most transformers are tested of PD activity during normal factory acceptance tests. Typical levels of PD activity are shown in Table 1.



Category	PD level – Pico-Coulombs
Defect Free	10 – 100 pC
Normal deterioration	< 500 pC
Developing Defects (irreversible damage to paper)	1,000 – 3,000 pC
Breakdown of oil	10,000 – 100,000 pC

Table 1
Common PD levels

Both electrical and acoustic PD detection each have advantages and disadvantages and are complimentary rather than exclusive. A partial discharge exhibits, besides other phenomena, a fast transient electrical pulse and an acoustic "bang". Depending of the location of the PD and the coupling path between the event and the detector, the electric or acoustic signal can be used to detect the PD. Both methods have different detection ways and sensitivities for unwanted signals (noise). The acoustic PD detection is most useful for events within the line-ofsight of the acoustic transducers. This limits the detection range, but also the amount of noise.

`` The electric PD detection covers a wider area, including e.g. bushing and tap changer. External noise will also be detected and is difficult to remove. The correlation between instrument reading and actual discharge magnitude is better than with the acoustic method. Several international standards exist that define the instrument response, which is the readout in pico-Coulomb or micro-Volt, allowing a better comparison between manufacturer and in-field measurements.

1. ELECTRICALMETHOD

The electrical signals from PD are in the form of a unipolar pulse with a rise time that can be as short as nanoseconds. The pulse rise time at the origin is dependent upon the type of discharge. Breakdown of an oil gap is a very fast process while a surface discharge may have up to ten times longer duration. PD pulses have wide frequency content at the origin. The high frequencies are attenuated when the signal propagates through the equipment and the network and pulse shape is also modified due to multiple reflections and exciting resonant frequencies of elementary circuits. The detected signal frequency is dependent on the original signal, pulse propagation path to the sensing point and the measurement method. Electrical PD detection methods are often hindered by electrical interference signals from surrounding equipment and the network. Most common and most difficult noise sources are aerial corona discharges and discharges to electrostatic shields that are not properly connected to either the HV bus or ground. Any on-line PD sensing method must have methods to minimize the influence of such signals. The most common method for PD detection is to decouple the High Frequency partial discharge signals using sensors that are capacitivly coupled to the HV bus (coupling capacitor). Most HV apparatus have a natural “capacitor” built into the HV bushings or CTs have a convenient point for connection of the PD instrument. Bushing test tap or CT shield leads are frequently used for partial discharge measurements along with power frequency insulation tests.

The most popular method to interpret PD signals is to study their occurrence and amplitude as a function of the power phase position; this is called phase-resolved PD analysis (PRPDA). This method can provide valuable insight into the type of PD problem present.

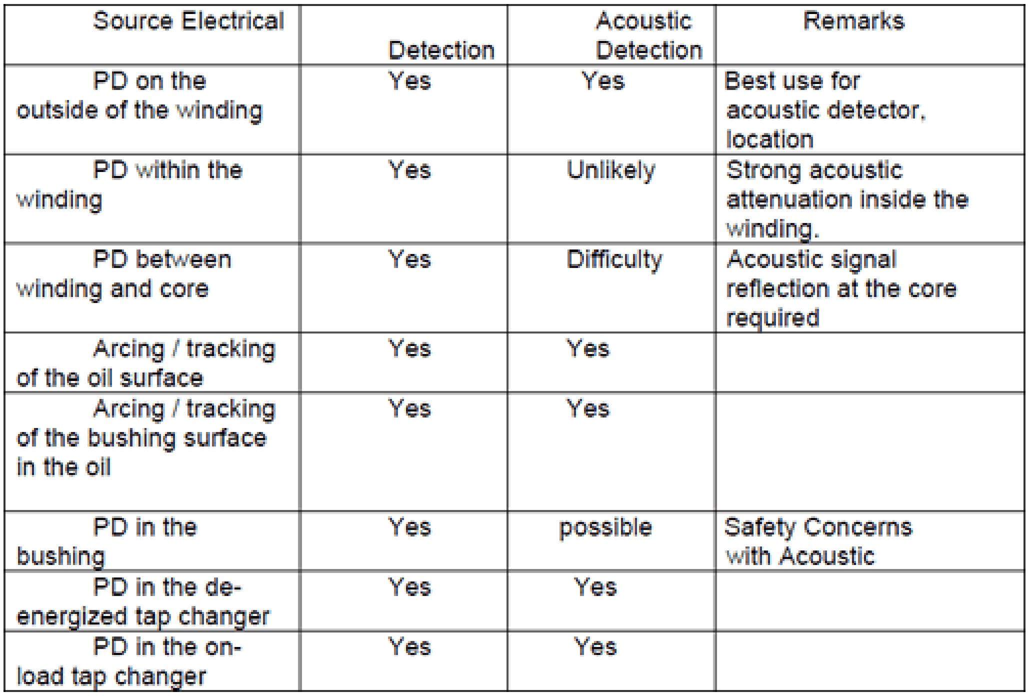
The best method of noise rejection for in field measurements employs the use of multiple sensors. Use of a single sensor model in the field is unlikely to produce satisfactory results. If several sensors of different types or at different locations are employed, the possibilities to reduce external influences are greatly enhanced. Generally, the multi-sensor approach can be split into two processes: separate detection of external signals and energy flow measurements.

Energy-flow measurements use both an inductive and a capacitive sensor to measure current and voltage in the PD pulse. By the tuning of the signals from the two sensors, they may be reliably multiplied and the polarity of the resulting energy pulse determines whether the signal originated inside the apparatus or outside. A modern PD instrument should employ both processes of the multi-sensor approach allowing the comparison of PD pulse magnitude from different sensors and pulses polarity for energy flow measurements.

2. <u>ACOUSTICMETHODS</u>

Acoustic emissions (AE) are transient elastic waves in the range of ultrasound, usually between 20 kHz and 1 MHz, generated by the rapid release of energy from a source. Partial discharges are pulse-like and cause mechanical stress waves (acoustic waves) to propagate within the transformer. If the stress waves propagate to the transformer tank wall, they may be detected with a transducer that is tuned to the right frequency.PD sources can be located by measuring the relative time of arrival of acoustic waves at multiple transducer locations.In typical applications, the signals from a group of externally mounted acoustic sensors are collected simultaneously and analyzed to detect and locate PD. However, as the acoustic tank signal propagates from the PD source to the sensor, it will generally encounter different materials. Therefore, acoustic signals can only be detected within a limited distance from the source. Consequently, the sensitivity for PD inside transformer windings, for example, may be quite low.Though not disturbed by signals from the electric network, external and internal influences in the form of rain or wind and non-PD vibration sources like loose parts, cooling fans and oil flow from transformer oil circulating pumps will generate acoustic signals that interfere with the PD detection. These non-PD acoustic signals may extend up to the 50 to 100 kHz region. To diminish the effects of this disturbance, acoustic sensors with sensitivity in the 150 kHz range are usually employed. Such sensors may, however, have less sensitivity to PD signals than lower frequency sensors.

<u>COMPARISON OF BOTH METHODS</u>



Source Electrical	Detection	Acoustic Detection	Remarks
PD on the outside of the winding	Yes	Yes	Best use for acoustic detector, location
PD within the winding	Yes	Unlikely	Strong acoustic attenuation inside the winding.
PD between winding and core	Yes	Difficulty	Acoustic signal reflection at the core required
Arcing / tracking of the oil surface	Yes	Yes	
Arcing / tracking of the bushing surface in the oil	Yes	Yes	
PD in the bushing	Yes	possible	Safety Concerns with Acoustic
PD in the de-energized tap changer	Yes	Yes	
PD in the on-load tap changer	Yes	Yes	

3. PD PATTERN CLASSIFICATION SYSTEM USING IMAGE ANALYSIS

Factory PD testing of new equipment is a routine test with a simple pass or fail outcome. For power equipment in service, on-line PD detection remains a challenge that is left for experienced personnel only, because the records always produce a PD pattern due to the presence of local electromagnetic interferences that cannot be controlled nor avoided. Local interference includes both synchronous and asynchronous signals. The former may be external corona, lose contact noise and power electronics employed in AVR´s to mention a few and the latter can cover signals from all new electronic gadgets, cell phones, WiFi, broadcasting stations and so far.Furthermore, electronics employed to monitor PD activity on-line can fail easily due to harsh environment conditions encountered at the installation site that include aggressive chemicals, extreme temperatures, mechanical shock, vibration and strong local magnetic fields or high transient over voltages found in normal power system plants. A faulty PD detector may also produce incoherent readings that can exceed acceptable levels and therefore trigger unwanted alarms. From so many source of interference, it is not a surprise to find that an unattended online PD system may be recording nothing but noise. The challenge for an on-line monitoring system is not only to record true PD activity, but also it requires a knowledge system that may be able to discriminate noise and accurately identify PD activity without the need for a continuous supervision from a PD expert.

To achieve this compatibility, Cladp´s input uses digital images in standard Joint Photographic Experts Group format (JPG). Such format is ready available on most digital PD detectors in the form of a file or it can be recovered from a printed report if it is scanned into jpg format. In this way, any digital detector can be converted into a continuous monitoring device using only its N-Q-□ PD pattern output. The structure of Cladp´s can be described in four modules, named: Input, de-noising, classification and labeling. In the input stage, the process is directed either to a single file or to a list of files or directory with jpg files. From that list, Cladp´s will produce a sorted output differentiating those files with noise from those with a PD pattern that require any action. In the de-noising stage and to produce reliable diagnosis, all patterns are analyzed to remove spurious and random noises. This feature is central to perform unattended and successfully all the classification procedure, preventing unwanted alarm issuing when high readings produced by external noise occur. For the classification module, PD activity is considered as a slow evolving activity that should be present during a considerable amount of time during monitoring. In this respect, the PD pattern is segmented according to its repetition rate and those sub-divided patterns are classified using morphological filters to fulfill all requirements stated in PD interpretation

3.2 INPUT STAGE

In the input stage, the process is directed either to a single file or to a list of files or directory with jpg files. From that list, Cladp´s will produce a sorted output in separated directories differentiating those files with noise from those with a PD pattern that require any action. All input files are kept unmodified and all output files had the same input name, but written in the appropriated directory. For a large number of files, an option to display in sequence all files, like in a movie is offered.

3.3 DE-NOISING STAGE

In the de-noising stage and to produce reliable diagnosis, all patterns are analyzed to remove spurious and random noises. This feature is central to perform unattended and successfully all the classification procedure, preventing unwanted alarm issuing when high readings produced by external noise occur. To achieve a 92% accuracy the Cladp´s PD pattern classification system starts with the raw information from monitoring systems or uses the conventional graphical output, with repetition number for the studied discharges N, generally coded as a HEX colour, the PD magnitude (Q), and the phase angle from the applied voltage (□), named as digital N-Q-□ pattern of most commercial Detectors, following the procedure outlined next. The digital N-Q-□ pattern is the output for a defined monitored period of PD activity. The importance of this surveillance time resides in the repetition rate expected for the PD that will shift the N value, allowing longer recording periods, in the range of 3 to 5 minutes, the appearance of well defined PD patterns even for sporadic activity. When intense interference is present, the recording time may be reduced to a few hundred cycles of the applied voltage, to prevent a complete overwriting of the PD pattern by interference or noise. The digital N-Q-□ pattern is then normalized to obtain only positive patterns and saved as a picture in the popular JPG format and handled as a matrix where all graphical filters are applied. The first graphical filter is a de-peg, that involves removing low repetition pixels from the image. This in physical terms is associated to spurious or low repetition rate signals that are not typical PD behavior but are registered by the PD detector. Then, repetition levels N originally recorded in 256 levels are reduced to 16 levels, by converting the image from colour to grey scale. This procedure allows the clustering of pulses with similar magnitude, broadening the clusters frontiers to account for randomness in PD levels caused by lack or delay of starting free electrodes. Furthermore, this permit the identification of asynchronous interference that can be identified as noise bands, since all asynchronous pulses will draw rectangular bands of roughly constant charge that are not related to PD and should therefore be removed.

3.4 CLASSIFICATION STAGE

For the classification module, PD activity is considered as a slow evolving activity that should be Present during a considerable amount of time during monitoring. In this respect, the PD pattern is segmented according to its repetition rate and those sub-divided patterns are classified using Morphological filters, as follows: The image after de-noising is left with synchronous records of pulses that are subjected to graphical operations of opening and closing. Opening is employed to isolate and differentiate study regions with different repetition rate. Once those study regions are named, a graphical closing operation is performed, using an adjustable mask with pixels sizes between 3x3 and 10x10 to fill an area and produce a homogeneous or linearly decaying study region. To locate a PD pattern each graphic zone is analyzed to identify a normal distribution. Then overlapping of a zone is determined by analyzing the contour of each pattern and assuming that the Normal distribution caused by one defect is partially hidden in the pattern corresponding to a seconded causing defect. Next the visible or non-overlapped area of the normal distribution under study is defined as those points ***a*** to ***b*** that correspond to an inflexion point where the next normal distribution appears. Then that area is calculated as the amount of pixels between **a** and **b**. This area is compared to an area generated using different ***k*** values between ***a*** and ***b***. ***(a*** and ***b*** corresponds to the area that contains non overlapped pattern and x Amp correspond to the phase angle where the maximum Amp is located, being ***k*** width and shape of the distribution).

4. PULSED X-RAY INDUCED PARTIAL DISCHARGE MEASUREMENTS

Measurement of partial discharges (PD) is a well established method for the detection of defects in high voltage insulation. The method is also used for routine testing of high voltage installations and components. However, the detection of small void defects by PD measurements is demanding, because the inception of PD in voids does not only depend on the local electrical field, but requires the presence of a start electron. In many cases, this start electron can only be provided by ionization bynatural background radiation. This means that there will be a delay between the application of sufficiently high field and the inception of the PD, called inception delay time. Owing to the statistical nature of the ionization process, the inception delay time will be randomly distributed, such that long measurement times are required to achieve reliable detection of small voids. Alternatively, start electrons can be created by field emission at sharp tips in the void. Usually, this mechanism requires higher fields, which means that the effective PD inception voltage is higher when the start electron can only be provided by field ionization. Earlier attempts to artificially provide start electrons by ionizing radiation succeeded only partially. While the inception time delay disappeared as predicted, the resulting PD signals were sometimes too small to be measurable in a typical test setup in production [1]. Other investigations show that constant irradiation of the insulator with x-rays can also suppress PD activity for high dose rates [2]. This indicates that the irradiation of the void during PD activity can strongly influence the dynamics of the PD process. It was therefore investigated if partial discharge pre-testing can be made more reliable by creating start electrons by ionizing radiation. A number of investigations on this subject were carried out in the past; the most comprehensive one was lead by Ontario Hydro in the 1990s. In these investigations, insulators samples were constantly irradiated with x-rays during the partial discharge measurement. This has indeed led to partial discharges in insulators in which none were detected without irradiation, however often with reduced magnitudes lower than 0.1 pC which would hardly be measurable in atypical factory environment. In the present investigation, extremely short X-ray pulses are used. The idea was to limit the influence of the ionizing radiation to provide a start electron, and not to influence the dynamics of the PD activity itself. Consequently, the X-ray pulses in the experiments were only applied immediately before the PD measurement, and not during the PD measurement.

4.1 THEORETICALLY EXPECTED VALUES

For spherical voids, the PD inception field can be predicted using the streamer criterion

$$fEo > Estr = [E/p]crit\ P[1 + B/ (pd)^{n}]$$

where

E0	applied field
(E/p)crit	25 V/(Pa m) for air
p	pressure in the void
B	8,6 m1/2 Pa1/2 for air
n	0,5 for air
f	1,33 for spherical voids in filled epoxy
d	diameter of the void

The exact pressure in the void is of course not known, but usual values range from 50 – 100 kPa .The expected PD inception background field was calculated for some pressures close to or in this range as a function of the void diameter.

4.2 DETECTION LIMITS

In this section, calculations are presented concerning the question under which conditions one can expect to detect all relevant void defects in an insulator. In this context, a relevant void is defined as a void in which PD inception can occur under service conditions. If one defines service conditions by a

maximum background field in service Eservice, this means that only voids of a certain minimum size dinc can show PD inception. Consequently, dinc can be calculated by solving Eq(1) for d, setting E0=Eservice. Whether or not PD in a certain void can detected during a test depends however on the apparent charge, which is a function of the actual PD charge and the coupling of the charge pulse to the measurement equipment.
For spherical voids, the magnitude of the charge induced in the electrodes is given by

$$q' = -\,(1/2)\pi\varepsilon\,\varepsilon\,d \cdot \Delta E \cdot \nabla\lambda_{r} \quad (2)$$

where d is the diameter of the void, ΔE is the field change in the void caused by the PD, and $\nabla\lambda_0$ is the gradient of the dimensionless scalar field at the location of the void, i.e. $\nabla\lambda_0 = E_{void}/U_0$ which is a property of the insulator design. The field change ΔE is a function of the PD magnitude. For the considerations regarding detection limits, ΔE is substituted with its maximum possible value, yielding q'_{max}, the maximum of the induced charge. If q'_{max} is higher than the noise level of the measurement system, the discharge is considered detectable.

4. ELECTRO-OPTIC MODULATION TECHNIQUE

The PD on-line monitoring technique is based on the use of a Lithium Niobate (LiNbO3) electro-optic (EO) modulator The measurement mechanism uses the measured PD signal and applies it across an optical fiber coupled LiNbO3 waveguide modulator, which modulates the intensity of the transmitted laser light as an approximately linear function of the voltage applied across it. The optical network supplies polarized laser light via polarization maintaining optical fiber to the LiNbO3 modulator input, and monitors the optical output from the modulator using an optical receiver. The EO modulator is compact and passive requiring no additional power to operate. The laser source, which is controlled by a temperature and current laser diode controller, has a wavelength of 1550 nm and maximal power of 10 mW. A polarization tuner was used to ensure that the input light for the modulator was linearly polarized. The optical receiver has a bandwidth of 1 GHz. Figure 2 shows the relationship between a single pulse from a signal generator applied across the EO modulator and the resultant output from the optical receiver. There is a slight delay between the two signals that have similar rise and fall times. The injected signal contains frequency components in excess of the useful bandwidth of the RFCT. It can be initially assumed that the method of transmission will not significantly alter the PD signal information.

Partial discharge (PD) detection is an important technique for assessing the health of high voltage power transformers. A partial discharge signal within an oil-filled power transformer may reach a winding first, then travel along the winding to the bushing core bar. The bushing, acting like a capacitor, can transfer the high frequency components of the partial discharge signal to its tap point. These high frequency components at the bushing tap point can be detected using a suitable sensor and transmitted to remote digital equipment for on-line analysis. In a high voltage substation there is often excessive electrical noise which may corrupt any measured PD signal from the bushing tap point as the bushing acts as an antenna. If signal transmission is implemented using standard coaxial cables this can result in further corruption of the PD signal. The use of optical transmission techniques therefore has clear advantages not only through improved noise immunity but also because it realizes electrical isolation and improved operator safety. So the application of an electro optic modulator to generate transmission signals over polarization maintaining optical fiber from the measurement point. The feasibility of this approach has been investigated using PD signals measured at the tap point of a 60kV bushing, two different PD sources have been used and in both cases it was possible to detect PD activity above 40p

5. COMBINATION OF DIFFERENT TECHNIQUES

The reliability of electrical energy networks depends on the quality and availability of primary electrical equipment such as the power transformer. Localized internal insulation failures can, however, lead to catastrophic breakdowns and incur high outage and penalty costs. To reduce such risks it is normal for power transformers to have passed a range of factory tests including one for partial discharge (PD) activity before acceptance and commissioning. Once installed it is costly to energies with e.g. induced test voltage or resonant sets, and the results are often restricted by high site interference. Many users then rely on integrated detection methods such the use of dissolved gases in the oils. However, this need not be the case. The UHF, acoustic and multi-terminal PD measurement methods are using different physical peculiarities of the PD phenomenon, e.g. electric currents according to IEC 60270 [1], electromagnetic waves (UHF-range) and acoustic radiation. The electrical PD-measurement set-up according to IEC 60270 usually has sensitivity limitations for on-site/on-line measurements because of the noise level in field. Due to the existing coupling of the three phases in a transformer, single partial discharge pulses in one certain phase can also be measured as cross coupling signals in all phases. Evaluation of multi-terminal PD measurements establishes an approach to clearly distinguish between multiple PD sources and to remove external disturbances. The so called “UHF PD measuring method” (UHF: Ultra High Frequency) is based on the facts that PD under oil are very fast electrical processes and radiate electromagnetic waves with frequencies up to the ultrahigh range (UHF: 300 – 3000 MHz). Due to the moderately attenuated propagation of UHF waves inside the transformer tank, the electromagnetic waves are detectable sensitively .UHF probes can be inserted into the transformer during full operation through the oil filling valve. As a result of shielding characteristics of the transformer tank against external electromagnetic waves, normally a clear decision can be made concerning the PD activity of the test object.

When electrical or UHF PD measurements confirm PD activity, a three dimensional localisation of PDsources is the next step for risk evaluation of PD phenomena. With three space coordinates and a time dimension relating to a single PD event, the number of unknowns’ requires four sensors for arrival time measurements and location. UHF technology offers this possibility but access for most designs is normally limited to 3 sensors or less. Because there is no limit in the number of piezo-electric acoustic sensors that can be mounted on transformer tanks, the acoustic measurements remains attractive for localization purposes. However, acoustic sensors are normally more sensitive to external disturbances than to the internal PD originated sound waves. They are also affected by distortion within the tank from the winding core and support structures in the transit path which influences partly can be eliminated with appropriate signal processing afterwards. The compromise is therefore, to use a combination of the two methods, using sensitive UHF signals to provide triggering and by using averaging of acoustic signals for de-noising.

CONCLUSION

Partial discharge (PD) detection is an important technique for assessing the health of high voltage power transformers. A partial discharge signal within an oil-filled power transformer may reach a winding first, then travel along the winding to the bushing core bar. The bushing, acting like a capacitor, can transfer the high frequency components of the partial discharge signal to its tap point. These high frequency components at the bushing tap point can be detected using a suitable sensor and transmitted to remote digital equipment for on-line analysis.A particular method can't be concluded as the most reliable one.through and through analysis about each method is needed for this.

SOME NEW GENERATION EQUIPMENTS AVAILABLE IN MARKET FOR PD MONITORING

1. PD SMART ELECTRICAL (USING CONVENTIONAL IEC60270 METHOD)
2. PD SMART ELECTRICAL (USING UHF METHOD)
3. PD GUARD(UHF METHOD)
4. PDL-650 OMICRON(ACCOUSTIC METHOD)
5. MPD-500 OMICRON(OPTICAL METHOD)

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