INTRODUCTION TO FUNDAMENTALS OF PD DIAGNOSTICS

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Preface

The electrical detection of partial discharge (PD) can be regarded as an important tool for both, quality tests on HV equipment in the laboratory and diagnosis tests on site. For a better understanding of the existing procedures for PD diagnosis tests some fundamentals on it shall be presented based on simple assumptions. The paper is especially intended as a guidance for the beginner in this subject in order to introduce him in a simple way to the very complex matter of PD diagnostics. In the following important questions, which are mostly asked by the testing engineer dealing with PD detection, shall be answered. In this respect the reader is recommended, to study carefully also the relevant IEC-Publication 270 "Measurement of partial discharges" [1].

1. How a PD is defined

Referring to IEC 270 [1] "a partial discharge, within the terms of this standard, is an electric discharge, that only partially bridges the insulation between conductors. Such discharges may, or may not, occur adjacent to the conductor. Partial discharges occurring in any test object under given conditions may be characterized by different measurable quantities such as charge, repetition rate, etc. Quantitative results of measurements are expressed in terms of one or more of the specified quantities."

The most important quantities, to be determined within an electrical PD test, are the apparent charge and the inception / extinction voltage.

2. Why PD ignite

Let us consider a simple electrode arrangement, which may be presented by a polyethylene-insulated power cable (Fig. 1). If subjected to a high voltage (HV), then the insulation inside the coaxial electrode arrangement is stressed by an electrical field. Because of the non-homogeneous field distribution a maximum field strength

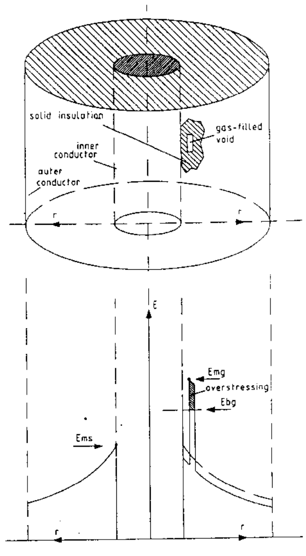

Fig.1: Field distribution in the presence of a gas-filled void in the solid dielectric of a cable

E_m exist, which appears usually at the inner electrode. The field strength is reduced more and more as larger the distance to the inner electrode is. The qualitative field strength distribution is drawn in the left part of Fig. 1.

HV equipment are designed in such a way, that the local stress never may exceed a critical strength, at which a breakdown occur and which is therefore called breakdown strength E_b. Of course, in this respect all possible voltage stresses in service have to be taken into account, including transient over voltages.

Despite careful dimensioning technological imperfection may occur in the insulation, like strange inclusions as cracks and gas-filled voids. In the following a gas-filled void shall be assumed in the insulation, which may giving rise to the ignition of partial discharges due to the following reasons:

On one hand, the permittivity of the gaseous insulation is always lower then those of solid dielectrics, which causes a local field enhancement in the air filled void, as drawn in the right part of Fig. 1. On the other hand, the breakdown strength of the gaseous insulation E_{bg} is much lower than those of the solid material E_{bs}. In Fig. 1 it is assumed, that the local maximum strength E_{mg} in the gas-filled void exceeds the breakdown strength E_{bg}, giving rise to gas discharges. If the boundary to the solid insulation is continuously exposed to those discharges, it may finally be deteriorated and lead to premature breakdown of the total arrangement.

Conclusions

PD are mainly caused by a local field enhancement, due to imperfections in the insulation, as for instance gas-filled inclusions as voids and cracks. With continued exposure to PD the insulation may fail. An early warning can be given if dangerous PD events are detected.

3. Why PD pulses appear

Let us again consider the example according to Fig. 1. The critical field region in the surroundings of the gas-filled void is drawn enlarged in Fig. 2. The assumed local field enhancement inside of the void, due to the lower permittivity of the gas compared to those of the solid dielectric, is shown in Fig. 2a. Under the assumed condition, that the maximum field strength in the gas-filled void is higher than the breakdown strength E_{bg}, a sudden ionization may be ignited. The number of the generated positive charged carriers is equal to those of the negative ones.

Due to the electrostatic field force the negative particles move into the direction of the inner electrode, if its polarity is positive as assumed in Fig. 2. Finally they are accumulated on the left boundary of the solid insulation, as shown schematically in Fig. 2a. Accordingly the positive particles move into the opposite direction and are accumulated at the right boundary. The so separated charge carriers produces its own partial field. This is superimposed on the static field, determined by the electrode arrangement. In this context it is important to note, that the polarity of the space charge regions in the void is opposite to those of the origin electrode arrangement, so that also the partial field strength is inverted, as evident from Fig. 2a. This results in a local field reduction inside of the void.

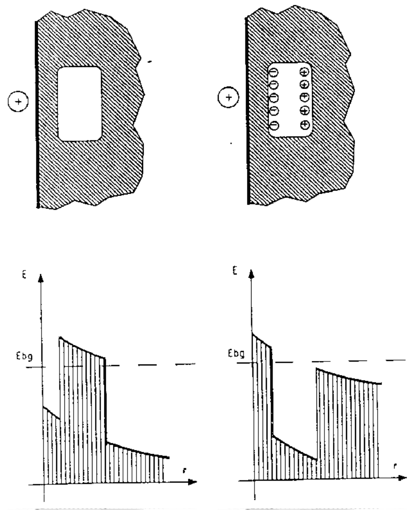

Fig.2: Changing of the field distribution due to the formed space charge of a single PD event

If it becomes lower than the critical value E_{bg}, as assumed in Fig. 2b, then an further ionization is impossible, i.e. the charge generation stops. The time interval between ignition and extinction of the ionization is extremely short, mostly below 100 nanoseconds. Hence each PD event is accompanied by an electromagnetic transient in the order of 100 ns.

Conclusion

Due to the formation of a space charge field which is directed opposite to the electrode field, the ionization processes causes its own extinguishing. The time from the ignition to the extinction of charge formation is in general below 100 nanoseconds. The appearing electromagnetic transients can advantageously be used for electrical PD detection.

4. Why sequences of PD events appear

After a space charge is formed and therefore after the mean field strength in the void is reduced drastically, a new PD event may ignited again, if the field strength in the void is increased again and exceeds the breakdown strength. In principle two reasons are responsible for subsequent individual PD events:

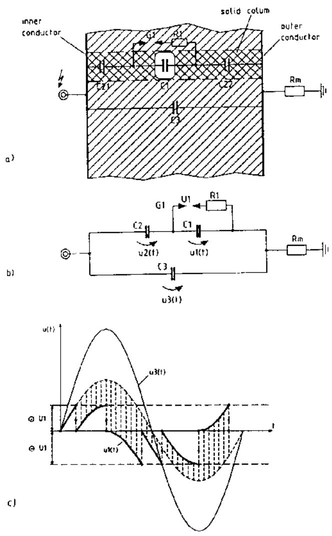

Fig. 3: Equivalent circuit for PD ignition

1. If the stressing voltage remains constant, i.e. a DC voltage is applied, then the necessary critical electric field can only be built up again, if the usually formed space charge dissipates. This is mainly caused by the recombination and diffusion of charge carriers. In general this requires a comparatively long time, especially for voids in high polymeric insulation, as polyethylene (PE). Hence for such dielectric material the PC repetition rate is extremely low, which seems to be a disadvantage for PD detection under DC stresses.

2. Subsequent PD events are also ignited, if the to the test object applied voltage is increased further so that the space charge field in the void may be again compensated. This is the case for alternating voltages and transient voltages like switching and lightning over voltages.

Because mostly AC testing is done, the appearance of sequences of PD pulses shall now be considered more in detail for alternating voltages. For this let us consider again a solid insulation having an imperfection like a gas-filled void, shown in Fig. 1. From this configuration an equivalent PD circuit can be derived. The in Fig. 3 presented circuit bases on a proposal of GEMANT and PHILIPPOFF [2], developed already more than 60 years ago.

Here the gas-filled void is substituted by a capacitor C_1 **,** to which a small air gap G_1 is connected in parallel, characterized by the breakdown voltage U_1 of the origin void. The resistor R_1 represents in connection with C_1 the transient process of charge formation, which can be expressed by a characteristic time constant:

$$T_1 = R_1 * C_1$$

The both dielectric columns, which are placed between the void and the both electrodes, are substituted by the capacitor C_{21} and C_{22} (Fig. 3a). Those can be summarized to the capacitor C_2, which is connected in series with C_1 (Fig. 3b). The total capacity of the test object is represented by C_3. According to practical experience the capacity of all three capacitors is extremely different, where the following conditions are mostly fulfilled:

$$C_1 \gg C_2$$

$$C_1 \ll C_3$$

$$C_2 \ll C_3$$

If an alternating voltage $u_3(t)$ is applied to C_3, then $u_1(t)$ occurs across C_1, which is reduced according to the divider ratio C_2 / C_1 (Fig. 3c). The gap G_1 across C_1 breaks down, if the critical voltage U_1, is obtained. This is the case, if the applied voltage $u_3(t)$ exceeds the crest value of:

$$U_{c3} = U_1 * C_1 / C_2$$

If the gap G_1 breaks down, i.e. the partial discharge is ignited, then the voltage across C_1 drops suddenly down within less than 100 nanoseconds to a very low residual value. Therefore, the voltage jump across C_1 is characterized approximately by the breakdown voltage U_1. After that the air gap obtains again its insulation performance. Hence, if the applied voltage $u_3(t)$ is increased further, also the partial voltage across C_1 is increased again. The changing of the voltage $u_1(t)$ is again determined by the divider ratio C_2 / C_1. Finally the critical voltage U_1, across C_1 is again obtained and a second breakdown appears. In this way a sequence of PD occurs in both half cycles

(Fig 3c). The pulse repetition rate is mainly determined by both, the frequency and the magnitude of the applied voltage.

Conclusions

Due to the capacitive coupling of the PD source to the terminals of the test object a partial voltage of the applied AC test voltage is transmitted to it. If the breakdown voltage is obtained, a suddenly voltage drop takes place, i.e. a PD occurs. The partial voltage U_1 can be rebuilt again, if the applied voltage is further increased. In this way a sequence of PD events appears.

From this follows also, that time interval between PD events is increased more and more as lower the frequency of the applied test voltage is. So at VLF or DC voltages the repetition rate of PD pulses becomes extremely low, which may be disadvantageously with respect to PD detection.

5. How PD faults can be classified

With respect to a simple consideration an inclusion in the solid dielectric, consisting of a gas-filled void, has been assumed above as an example. In practice, however, a lot of different PD faults may happen. The most important kind of PD sources can be represented to a limited number, represented by typical fundamental electrode arrangements, as shown in the following.

As previous discussed, PD are caused by local field enhancements and appear in weak regions, as in gas-filled voids. Of course, PD may appear also in pure gas insulation as either in ambient air or in SF6 insulation. Hence, the local field enhancement can be limited by a point electrode in air. Furthermore, dielectric interfaces can be simulated insulating barriers, if placed between the electrodes in a point-to-plane gap, and will be shown below.

Let us first consider a PD source in the ambient air. It may be caused, for instance, by a small protrusion at the surface of an HV shielding electrode (Fig. 4.) This PD source can be represented by a simple point-to-plane gap.

If such arrangement is subjected to an AC test voltage, which exceeds the PD inception voltage, then the first PD pulses are ignited in the negative half cycle, which appear in the surroundings of the crest of the applied voltage. Those PD events are known as TRICHEL pulses. If the test voltage is increased more and more, then finally PD may happen in the positive half cycle. The magnitude of positive pulses is much higher compared to those in the negative half cycle, but the pulse repetition is much lower. In this context it should be mentioned, that the pulse repetition rate of the TRICHEL pulses at increasing test voltage may increase up to the MHz range. Furthermore, they may also disappear, because of transition into a DC like current, so called pulse-less discharges.

Another typical PD fault may appear, if a metallic of floating potential approaches the HV electrode. Such constellation may

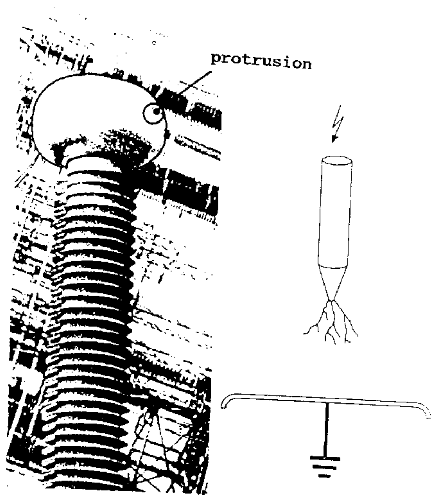

Fig.4: Protrusion at a HV electrode simulated by a simple point-to-plane gap

arise by corrision of connecting structures, as assumed in Fig. 5. Under such condition the capacitive potential distribution may cause bursts of sparks. They appear at every half cycle in a region, at which the changing of the applied AC voltage becomes a maximum, i.e. in the surroundings of the zero-crossing between the half cycles. This arrangement can be simulated by a point-to-plane gap, having an additional third electrode between the intermediate space, as shown in Fig. 5.

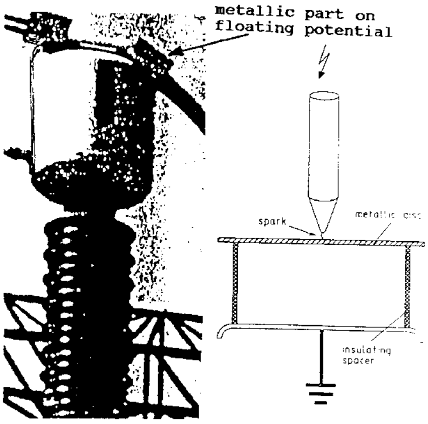

Fig.5: Potential-free metallic part simulated by a point-to-plane gap and a metallic disc inside

A further kind of PD source is shown in Fig. 6 . It refers to surface discharges, which may appear in the end region of coaxial electrode arrangements, as PE cables. The characteristic PD behavior can be simulated by a point-to-plane gap, where an insulating barrier is placed between. This configuration is well known as TOEPLER arrangement. The appearing sliding discharges are characterized by extremely high PD magnitudes, ranging between some 1000 pC and more than 100000 pC. They appear in each half cycle before the crest of the applied AC voltage is obtained and disappear immediately after that.

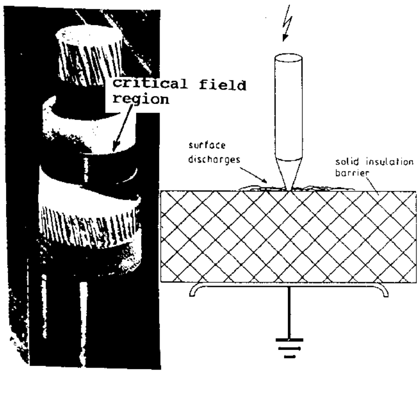

Fig 6: Simulation of surface discharges by a TOEPLER arrangement

Finally also inclusions in solid insulation, as gas-filled voids and cracks, can be simulated by a point-to-plane arrangement if an insulating barrier is put between the electrodes. Different from the previous presented classical TOEPLER arrangement it has to be looked for, that between the point electrode and the insulating barrier a small air gap in left, as evident from Fig. 7.

Furthermore, the applied test voltage has to be limited to such a magnitude that no sliding discharges may occur. Under this condition the PD pulses appear in the region of the zero crossing at each half cycle.

Conclusion

The in practice known characteristic PD failures can be simulated by simple point-to-plane arrangement. In this context it has to be noticed that the presented examples are intended only, to give the beginner in PD diagnostics a preliminary intention on characteristic PD events. In practice, however, extremely complicate cases may arise, which makes the recognition of critical PD sources more difficult. It should be noticed, that recent computer-aided PD measuring systems are available, which may be helpful for further identification of PD events. Two powerful PD diagnosis systems, called “LDS-4“ and “TEXpert“, are also offered by LEMKE DIAGNOSTICS.

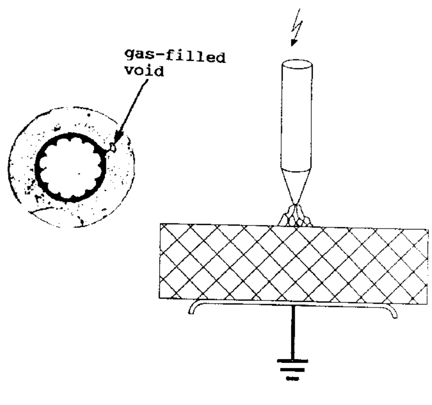

Fig.7: Simulation of PD in gaseous inclusions

6. How the apparent charge is characterized

In order to detect PD events according to the relevant standard a coupling unit has to be connected to the terminals of the test object, as specified in IEC 270 [1]. In this respect it seems to be of interest, which part of the “inner“ space charge, generated by a PD ignition inside the origin PD source, can be detected “outside“ at the terminals of the test object, where the latter is quantified as apparent charge.

For this let us consider again the equivalent PD circuit according to Fig. 3. With respect to simple calculations the following quantitative values shall be introduced:

- Breakdown voltage of the gap C_1:
  $U_1 = 1$ kV

- Capacity of the PC fault:
  $C_1 = 1$ pF

- Capacity of the solid column:
  $C_2 = 0.01$ pF $= 0.01 * C_1$

- Capacity of the test object
  $C_3 = 100$ pF $= 10000 * C_2$

If an alternating test voltage $u_3(t)$ is applied to the terminals of the test object, having the capacity C_3, then only about 1 % of the test voltage occurs across C_1 because it is divided according to the capacitive ratio C_2 **/** C_1.

If the crest voltage of u_3 (t) exceeds a critical value of 100 kV, then the breakdown voltage $U_1 = 1$ kV across C_1 is obtained. The breakdown event causes a voltage jump of about $U_1 = 1$ kV. This is transmitted via C_2 to the capacity C_3 and therefore reduced by the ratio C_2 **/** C_3, which is previous assumed as
0.01 / 100 = 10,000. Therefore, the voltage jump $U_1 = 1$ kV causes only a step of 0.1 V across the test object capacity C_3.

Based on this example the “inner“ pulse charge Q_1 and the “outer“ pulse charge Q_3 can be determined in a simple way:

$Q_1 = U_1 * C_1 = 1$ kV * 1pF:
$Q_1 = 1000$ pC

$Q_3 = U_3 * C_3 = U_1 * C_2 = 1$kV * 0.01 pF:
$Q_3 = 10$ pC

$Q_3 / Q_1 = C_2$ **/** C_1
$Q_3 / Q_1 = 0.01$

That means, that the at the terminals appearing pulse charge Q_3 in essentially reduced, if compared to the origin pulse charge Q_1. The attenuation ratio is determined by C_2 **/** C_1, which is in general not known. Hence, the at the terminals of the test object detectable charge is called “apparent charge“ [1].

Conclusions

Compared to the in the PD source generated charge, the at the terminals of the test object detectable “apparent charge“ appears extremely reduced. The attenuation is mainly determined by the ratio between the capacity of the solid column C_2 and the equivalent capacity C_1 of the origin PD source. Both values are not known generally. This fact can be considered at the most weakest point with respect to PD diagnostics.

7. How to calibrate the PD circuits

If we consider Fig. 3a and 3b, then it seems evident, that the at C_3 appearing pulse charge results from the voltage jump across the PD fault which is transmitted via C_2, representing the capacity of the solid column between the PD fault and the test object terminals.

This internal charge injection can also be simulated by an external charge injection into the terminals of the test object, as shown in Fig. 8. Here the gap C_1 is substituted by a fast voltage step generator G_c, which has to be driven potential-free, i.e. it must be battery-driven. In accordance to U_1 a voltage step of U_c is generated. The capacitor C_2 is substituted by a calibrating capacitor C_c. Under the condition

$C_c \ll C_3$

the to the terminals of the test object transmitted calibrating charge can be evaluated in a simple way as:

$Q_c = U_c * C_c$

Taking into account the charge formation in real PD sources the duration of the injection of calibrating pulses must be limited below 100 ns.

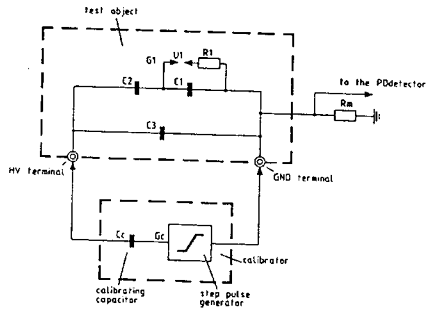

Fig. 8: Calibration procedure for the apparent charge

Based on the above presented procedure the PD quantity “apparent charge“ is defined in accordance to IEC 270 [1] as follows:

“The apparent charge q of a partial discharge is that charge which, if injected instantaneously between the terminals of the test object, would momentarily change the voltage between its terminals by the same amount as the partial charge itself. The apparent charge is expressed in picocoulombs.“

In addition to this the following notes are given:

1. The apparent charge is not equal to the amount of charge locally involved at the side of the discharge and which cannot be directly measured.

2. In practice, the waveform of the voltage appearing across the terminals of the test object due to the partial discharge itself may be different from that produced by the calibrating pulse. The apparent charge is considered to be such charge which, if injected between the terminals of the test object, will give the same reading on the measuring instrument as the partial discharge itself. Special cases are those in which the test object include traveling wave or attenuation phenomena.

Conclusions

The at the terminals of the test object detectable PD quantity “apparent charge“ is a measure of the PD event, but it is not equal to the amount of charge locally involved in the origin PD source. In order to quantity the apparent charge, calibrating pulses have to be injected into the terminals of the test object. The calibrator consists in principle of a battery powered step pulse generator, which is connected to the test object via a small calibrating capacitor.

8. How PD events can be detected

As presented previous, the by the breakdown of the gap G_1 caused voltage jump U_1 is transmitted via C_2 to the terminals of the test object, having the capacity C_3 .Hence it is reduced according to C_2 / C_3. This statement, however, is only valid, if the test object is not simultaneously discharged. In practice this condition can not be fulfilled, as discussed below.

With respect to practical PD detection let us assume, that the test object represented by the capacity C_3, is grounded via measuring impedance, which is simulated by a resistor R_m in Fig.3. Then the equivalent time constant T_m of the PD measuring circuit can be expressed as:

$$T_m = R_m * C_3$$

According to physical studies of PD phenomena the charge formation in the PD source can be approximated by an exponential function, characterized by a pulse decay-time constant T_p. Then the voltage drop across C_1 is given by:

$$u_1(t) = U_1 * \exp(-t / T_p)$$

In most cases the charge formation due to a PD event is finished after about 100 ns, as mentioned previous. This time corresponds to approximately 3 * T_p .

Hence, the PD pulse decay-time constant of

$$T_p = 30 \text{ ns}$$

shall be introduced for further quantitative considerations.

In order to avoid a remarkable discharge of the test object capacity C_3 via the measuring impedance R_m (Fig. 3) during the space charge formation, the measuring circuit time constant should be chosen much higher than the pulse decay-time constant T_m . This requirement is well fulfilled for

$$T_m > 10\ T_p\ ;\ T_m > 300\ \text{ns}$$

If a measuring impedance R_m = 50 Ohm is applied, which corresponds to the characteristic impedance of usual measuring cables, then this condition is only fulfilled for test object capacities C_3 larger than 6000 pF.

In practice the test object capacity is often much lower than 6000 pC. Under this condition the integration capability of C_3 is reduced more and more as lower the test object capacity is. To overcome this disadvantage, commercially available PD detectors for measuring the apparent charge are designed like quasi-integrators, as reported below.

Conclusion

Due to the integration performance of the test object capacity the apparent charge can be derived directly from the voltage jump, which is detectable at the terminals of the test object. For this, however, the time constant T_m of the measuring circuit must be much larger than the pulse decay-time constant T_p which characterized the duration of the charge formation inside the PD source.

For test objects of low capacity, say below 5000 pC, this condition is not longer fulfilled. Hence, the amplifier of PD detectors is usually designed as a quasi-integrator, having a band-pass filter characteristic.

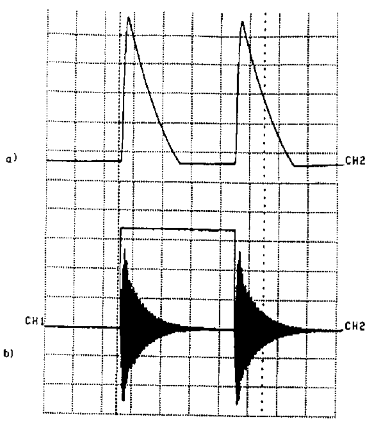

Fig.9: Characteristic step responses of the wide-band PD detector LDS-5 obtained at the output CHARGE (a) and those of a narrow-band amplifier (b)

9. How PD detectors can be characterized

As mentioned above, PD detectors for measuring the apparent charge must have a suitable integration capability. That means, the characteristic integration time constant T_i must be much larger than the pulse decay-time constant T_p . This condition is in general well obtained, if the condition

$$T_i > 10 * T_p$$

is fulfilled. With the previous introduced value T_p = 30 ns follows the requirement

$$T_i > 300\ \text{ns}$$

Because the usual amplifiers can be characterized by the invariant condition

$$T_i * f_1 = 0.15$$

The upper cut-off frequency f_1 can be expressed as

$$f_1 < 0.015 / T_p$$

For the assumed value of T_p = 30 ns follows, that the upper cut-off frequency for amplifiers measuring the apparent charge should be limited below f_1 = 500 kHz.

The choice of the lower cut-off frequency f_2 seems not so critical. It is mostly determined by the capability for elimination of the influence of harmonics due to the AC test voltage. Practical PD test circuits are characterized by f_2 ranging between 50 and 200 kHz.

Depending on the used bandwidth

$$Bf = f_2 - f_1$$

It can be distinguished between wide-band and narrow-band PD measuring systems. The wide-band PD processing is characterized by a bandwidth close to f_2 , which obtains in practice several 100 kHz. As an example Fig. 9a shows the step response of the PD detector LDS-5.

The narrow-band processing is characterized by a band-width which is much lower than f_1 and causes an aperiodic oscillating response as evident from Fig. 9b. The damping of the oscillations becomes lower as lower the bandwidth is. Hence, the advantage of selective amplifiers with respect to the elimination of radio interference (RIV), may cause fatal superposition errors if subsequent PD events occur. Hence, attention has to be paid, if narrow-band amplifiers are used as also remarked in IEC 270 [1]. Furthermore, the pulse polarity can not be recognized, disadvantageously for PD fault location.

Conclusion

In principle it can be distinguished between two procedures of measuring the apparent charge, the wide-band and the narrow-band PD detection.

With respect to RIV noise suppression the application of the narrow-band procedure seems advantageously. In this respect, however, it has to be taken into account, that fatal superposition errors may occur, if the PD pulse repetition rate exceeds some kHz, because of the comparative long setting time of usual narrow-band amplifier, especially developed for RIV measurements. Narrow-band amplifier may not identify the pulse polarity and can in general not be applied for PD fault location.

Hence, the wide-band-PD detection should be preferred, if possible. The advantage of this is, that superposition errors may occur only, if the repetition rate exceeds several 10 kHz. Furthermore, it offers advantageously possibilities for PD fault location. In this respect also the advantages for computer-aided PD processing have to be mentioned, which is extremely restricted in case of narrow-band PD detection. More advantages of wide-band PD detection are presented in the following.

10. What are the advantages of the LDS-5

In commercially available PD detectors the required PD pulse integration is usually carried out by amplifiers of a band-filter characteristics, as described above.

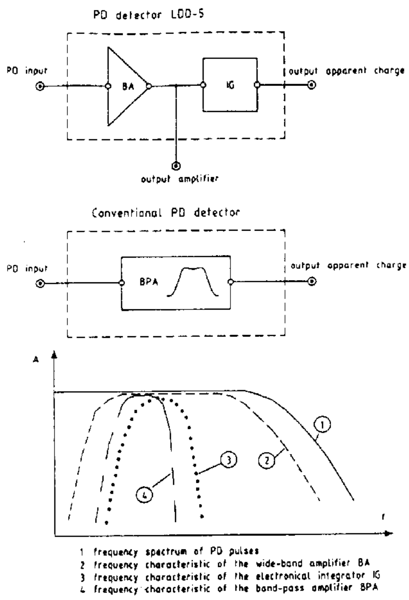

Fig.10: Bloc diagram and frequency characteristics of the LDS-5, compared to those of conventional PD detectors

In the LDS-5, however, the necessary integration is carried out separately from the amplification of the PD pulses. That means, the PD pulses are first amplified, for which a wide-band amplifier is used, which upper cut-off frequency in more than 50 times higher, than those required for the PD pulse integration in order to obtain the apparent charge. The integration is not made by a band-pass amplifier but by a special developed electronic integrator, which can be controlled and which separates the PD pulses according to their polarity. With respect to the detected apparent charge, however, there is no fundamental difference between the LDS-5 and other commercial available PD detectors, if only the PD input and the output apparent charge like a black box (Fig. 10) is considered.

The in the LDS-5 used integrator is characterized by an integration time constant T_i of about 0.5 µs, which corresponds to an equivalent upper cut-off frequency of about 300 kHz.

The main difference between the LDS-5 and other available PD detectors is characterized by the following:

a) The output “AMPLIFIER“, characterized by an upper cut-off frequency above 30 MHz is advantageously applicable for PD fault location on long lengths of PE-cables, based on the well known PD pulse-reflectrometry. Furthermore, the identification of PD events according to their origin occurrence seems useful for studies in research and education, dealing with the nature of PD. To this output also a spectrum analyzer or a powerful computer can be connected.

b) The output „POLARITY“ offers additional possibilities for PD fault location on short lengths of cables, using the differential PD bridge procedure.

c) The output “SCOPE X“ and “SCOPE Y“ allow additionally to the usual display of PD pulses on a linear time-base also a convenient display on an elliptical time-base which rotates synchronously with the test voltage frequency.

d) The modes for noise reduction increase the field of application not only in well shielded test laboratories but even under noisy condition. The influence of radio interference voltages (RIV) can be reduced if „RIV RED“ is switched on. Furthermore, stochastically appearing pulse shaped noises, as for instance caused by thyristors or switching over voltages, can effectively be suppressed. For this they are picked up by an electromagnetic sensor, which is connected to the input „SENSOR“. According to the noise magnitude the desired trigger level can be adjusted. Under this condition measuring windows are generated automatically, free of external disturbances.

e) The pulse resolution performance of the LDS-5 can be evaluated as excellent compared to those of other PD detectors. No significant superposition errors occur down to a pulse distance of a few of µs, which corresponds to a pulse repetition rate of more than 100 kHz. Of course, in practical measurements superposition errors are not recognized, because no comparative measurement is done, using an equipment free of superposition phenomena.

Conclusion

In the LDS-5 the PD pulse processing is done in the following two steps, first the extra wide-band amplification and after that an electronic integration. This procedure offers additional possibilities for evaluation of PD events. So besides the detection of the apparent charge a pulse reflectometry can be done with respect to PD fault location. Furthermore, possibilities for reduction of the influence of external noises are given.

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