STATIC VOLTAGE SOURCE USE TO SUPPLY PARTIAL DISCHARGE MEASURING CIRCUITS AT INSTRUMENT TRANSFORMERS

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Abstract **– The paper presents the implications of static voltage source use in the partial discharge (PD) measuring circuit at instrument transformers. The economic advantages deriving from the use of such sources must be correlated with the technical requirements dealing especially with the sensitivity of PD measuring circuit. So, the paper presents the evaluation of the common mode disturbances introduced by the said sources and the solution adopted for their attenuation.**
The authors evaluated the common mode disturbances in the PD measuring circuit, including the static voltage source, both by their direct measurement using a disturbance measuring instrument and by the way they were quantified by the PD measuring system. So, it could be rendered evident that at the same voltage level (5kV) and different frequencies (50Hz, 100Hz), disturbance presence influenced the PD measuring system sensitivity not allowing the measuring of a PD level lower than 8pC.
The solution for common mode disturbance attenuation consisted in using an insulating transformer at the output of the voltage source, that represents an efficient way to interrupt the grounding loops especially in the case of low and medium frequency disturbances. The PD measuring circuit which integrates the solution for common mode disturbance attenuation was experimented for the complete sequence testing of two 24 kV instrument transformers, current and voltage. Besides the problems related to the correlation of the parameters: high voltage, low voltage, current absorbed at different testing frequencies (50Hz,100Hz) defining the limits determined by the source power, a circuit background noise lower than 1.2pC was rendered evident indicating its very good sensitivity.

Keywords: *partial discharge, common mode disturbances, static voltage source*

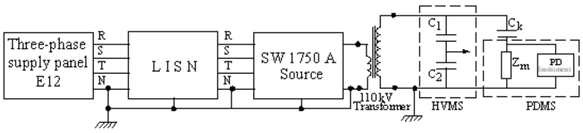
1. INTRODUCTION

Partial discharge (PD) measurement at instrument transformers is carried out according to the international product standards together with the power frequency withstand voltage test of the primary windings, as routine test [1,2].
The testing circuits are standardised and require test voltage application on the primary winding of the instrument transformer.
Generally, the use of high voltage and power testing transformers for voltages lower than 70kV may bring to discussion whether it is profitable to perform such test or not. Moreover, at inductive voltage transformers, when performing induced voltage withstand test where it is necessary to raise the test voltage frequency, solutions which to avoid the use of a motor-generator group, with the associated technical and economic inconveniences, are requested.
That is why, solutions to achieve some testing circuits which not to request the use of expensive sources, from the consumed power viewpoint, for voltages lower than 70kV which to solve the problems related to PD measurement circuit sensitivity were searched. The paper presents the generation circuit for high voltages up to 70kV consisting of a 2kVA transformer supplied from a static source as well as how common mode disturbance attenuation was achieved.

2. EVALUATION OF COMMON MODE DISTURBANCES

The use of the programmable power source type SW1750A [3] rendered evident a series of problems like the presence of common mode disturbances appearing at the three phase supply of the source and the defining of PD measuring circuit parameters in the conditions of limited source power.
Common mode disturbance evaluation was performed introducing the testing circuit elements by turns starting from the three phase supply panel (380V), using a voltage probe and a disturbance measuring instrument.
The disturbances were measured in the frequency range 0.03MHz-0.5MHz, characteristic to the bandwidth of the PD measuring instrument [4].
The circuit evaluated from disturbance viewpoint which contains LISN (Line Impedance Stabilization Network) to filter the electromagnetic interferences transmitted on the supply lines is presented in Fig.1.
Although the SW1750A source offers a galvanic isolation, namely source neutral is isolated to ground and to the output, its connection to the three phase supply with earthed neutral cancels this advantage.
After a no-load source evaluation (input and output disturbance measurement) the partial discharges and the conducted disturbing voltages were measured simultaneously when a voltage of 5.5kV, frequencies of 50Hz and 100Hz were got in the circuit from Fig.1.

It could be also noticed the influence of SW 1750A source output activation on the indication of the PD measuring system.
So, Figs. 2,3,4,5 present the disturbances recorded both at no-load source operation (input and output) and at load (consisting of the PD measuring circuit elements) operation (5.5kV voltage, 50Hz and 100Hz frequencies).
At the same time, Figs. 6,7 present the records of the PD measuring system at the same voltage level and at 50Hz and 100Hz frequencies.



HVMS – HV measuring system
C_k – coupling capacitor 500pF/300kV
PDMS – PD measuring system

Figure 1: Circuit for disturbance evaluation at PD measurement

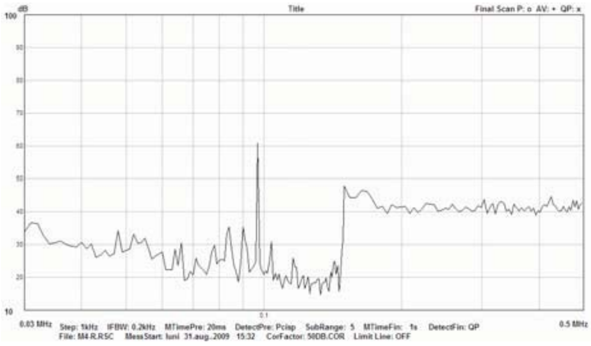


Figure 2: Phase disturbance measurement at SW 1750A source input

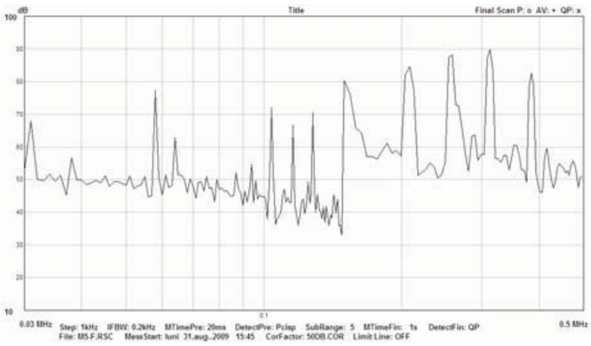


Figure 3: Phase disturbance measurement at no-load SW 1750A source output

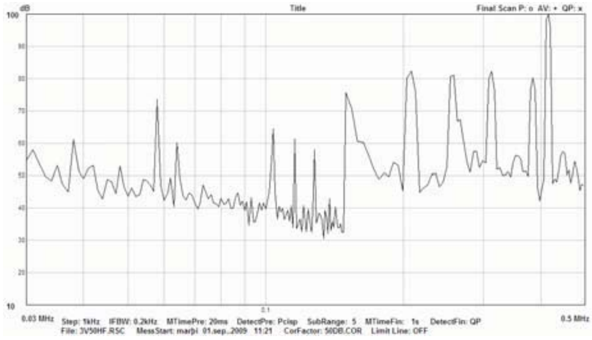


Figure 4: Phase disturbance measurement at SW 1750A source output at 30V (5.5kV), 50 Hz

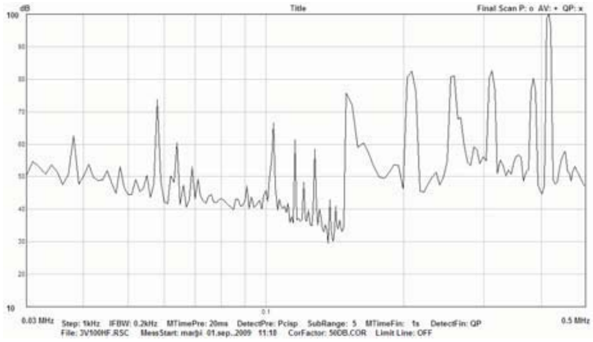


Figure 5: Phase disturbance measurement at SW 1750A source output at 30V (5.5kV), 100 Hz

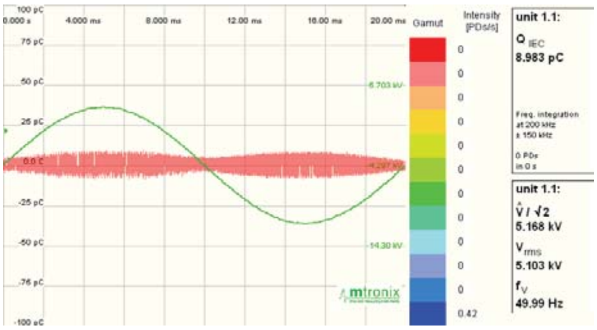


Figure 6: PD measurement at 5.5kV, 50Hz

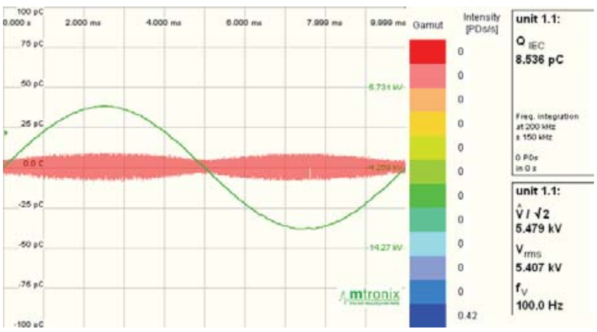


Figure 7: PD measurement at 5.5kV, 100Hz

The amplitude difference appearing around 0.15MHz (Figs. 2,3,4,5) is due to the automatic change of electromagnetic disturbance receiver bandwidth from 200Hz to 9kHz.

It is noticed the presence of common mode disturbances that are transmitted from the three-phase supply in the PD measuring circuit and alter its sensitivity because they do not allow a PD level lower than 8pC to be measured.

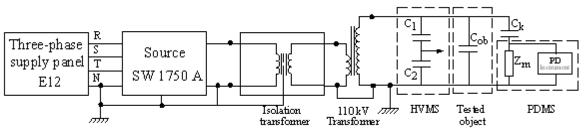
At the same time, it is only SW 1750A source activation that leads to measuring disturbing pulses of about 3pC, in the conditions of PD measuring system calibration with 25pC.

It was necessary to apply some solutions which to lead to an improvement of PD measuring circuit sensitivity.

3. EXPERIMENTS FOR PD MEASURING CIRCUIT OPTIMISATION TO ATTENUATE COMMON MODE DISTURBANCES

Due to the performed tests, a PD measuring circuit (Fig.8) attenuating the common mode disturbances and allowing instrument transformer testing at 50Hz and 100Hz frequencies was finalised.

The adopted solution was the use of an isolation transformer at the programmable power source output that represents an efficient mean for breaking the grounding loops, especially in the case of low and medium frequency disturbances [5, 6].



HVMS –HV measuring system
C_k – coupling capacitor 500pF/300kV
PDMS – PD measuring system

Figure 8: Disturbance attenuating circuit at PD measurement

This testing circuit was used for PD measurement at two 24kV instrument transformers – current and voltage, that request standardised testing procedures involving an insulation pre-stressing voltage (power frequency withstand voltage) to be applied for maximum 1 min and the voltage to be decreased to specified values to which the PD level is measured [1,2].

In the above circuit, the correlation between the parameters: high voltage, low voltage, current absorbed at different testing frequencies (50Hz,100Hz) was also evaluated to determine the limits owed to SW 1750A source power.

The testing circuit for the two types of instrument transformers is presented in Fig.9 and the test results with applied voltage levels and PD recorded values are presented in Figs. 10, 11.

As it can be noticed in Figs. 12,13, at a voltage of 17kV, the PD measuring system recorded a background noise whose level was lower than 1.2pC, that is a very good sensitivity of the PD measuring circuit.

The developed circuit enabled the full testing of the two 24 kV instrument transformers, the power source domain having the parameters: 270V, 6.5A, 50Hz was used for the current transformer and the power source domain with the parameters: 135V, 13A, 100Hz for the voltage transformer.

Figure 9: PD measuring circuit at a 20√3//0.1/√3//0.1/3V voltage transformer

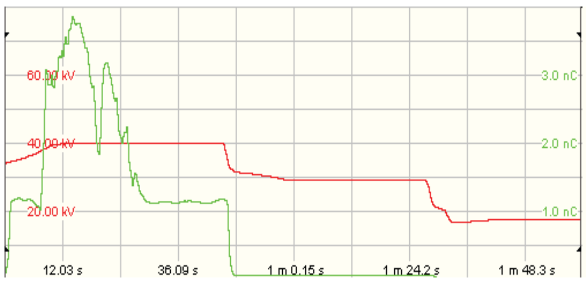


Figure 10: Testing sequence at a 24kV, 400/5/5A current transformer

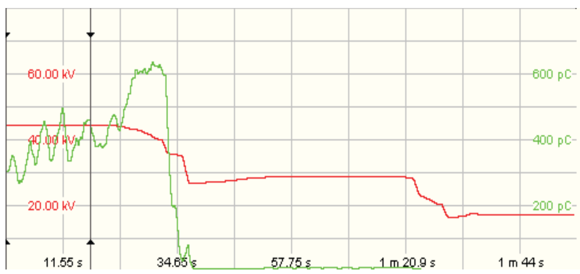


Figure 11: Testing sequence at a 20√3//0.1/√3//0.1/3V voltage transformer

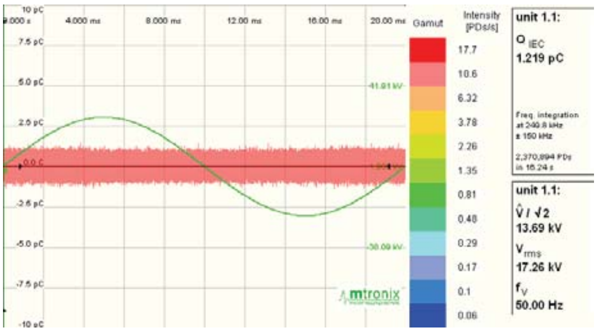


Figure 12: PD measurement at 17kV at 24kV, 400/5/5A current transformer

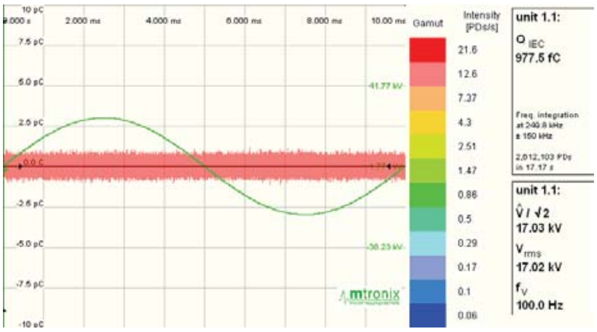


Figure13: PD measurement at 17kV at 20√3//0.1/√3//0.1/3V voltage transformer

However, PD measurement results and circuit parameter correlation depending on load rendered evident that if when measuring PD at 50Hz test voltages it is possible to reach a 63.5kV voltage (source domain: 270V/6.5A), but at 100Hz (source domain: 135V/13A) this is not possible any more.
So, for a 36kV inductive voltage transformer at 42kV the source power limits, namely 134V/7.2A are already reached, that represent the maximum power on the selected domain 135V/13A.
For 36kV insulation class it is necessary to use a higher power source which to allow PD measurement according to the procedures specified in the product standards of instrument transformers.

4. CONCLUSIONS

Static voltage source use to supply the PD measuring circuit at instrument transformers rendered evident the fact that the three phase supply from voltage networks with earthed neutral lead to the appearance of common mode disturbances. These disturbances were evaluated and solutions for their attenuation which to enable low level PD measurement were implemented.
So, the developed circuit enabled PD measurement in complete measurement sequence at 24kV current and voltage transformers, the background noise level of this circuit being lower than 1.2pC.
Static voltage source use to supply PD measuring circuits at medium voltage instrument transformers represents a profitable solution from the viewpoint of the involved energy consumption as well as from the one of the time and personnel necessary to achieve the measurement.

References

[1] IEC 60044-1:2003, Instrument transformers – Part 1: Current transformers.
[2] IEC 60044-2:2003, Instrument transformers – Part 2: Inductive voltage Transformers.
[3] Operation Manual SmartWave™ Switching Amplifier, SW 1750A model, ELGAR ELECTRONICS CORPORATION, SUA.
[4] IEC 60270:2000, High-voltage test techniques – Partial discharge measurements.
[5] I. Dumbravă, A. Marinescu, *Măsurarea numerică a fenomenelor tranzitorii în laboratoare, stații şi rețele de înaltă tensiune*, Editura Electra, Bucureşti, 2005.
[6] A.J. Schwab, *Compatibilitatea electromagnetică*, Editura Tehnică, Bucureşti, 1995.