



Experience with On-Line Insulation Diagnostics of Surge Arresters By Partial Discharges Measurement in the Field

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- As surge arresters are directly connected to high voltage, any fault can have serious consequences to the system.
- The integrity's analysis of surge arresters in service is traditionally performed by the measurement of the leakage current and thermography.
- Another effective tool is the measurement of Partial Discharges (PD). PD measurement can be used to evaluate the health condition of those equipments during their normal operation, without necessity of their disconnection from the electrical system.
- This work describes the experience applying a simple methodology to evaluate surge arresters in the field, measuring PD through a high frequency current transformer (HFCT) connected to the grounding cable using a modular digital oscilloscope and a laptop PC.

- When a HFCT is used for measuring partial discharges, the use of impedance measurement, also known as quadrupole, are eliminated.
- Moreover, the use of HFCT provides Galvanic isolation between the PD meter and high voltage circuit, increasing the levels of safety of persons and the instruments used in the test.
- However, the big advantage of use of HFCT is the low impact on electrical system, because there is no need for interruptions in the flow of energy.

- The HFCT used in test are of type bipartite (Clamp). This allows the installation of HFCT, for the most part, to take place in normal conditions of operation, embracing the conductor that connects the surge arresters to the ground.



Evaluation of the HFCT for PD Measurement

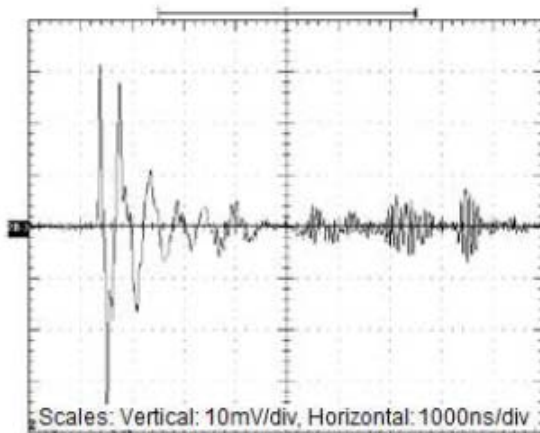
● The conventional methodology for measurement of partial discharges using a coupling capacitor and a measurement impedance (coupling device) was used as a reference when assessing the sensitivity of HFCT.

1 – Applying a known calibration pulse and registering it through the HFCT grounding cable connected to the object under test.

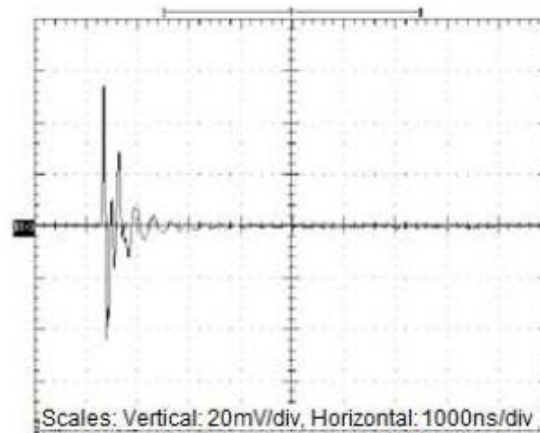
2 – Apply increasing values of voltage to the object under test until the nominal value, registering partial discharge signals detected by HFCT by an oscilloscope.



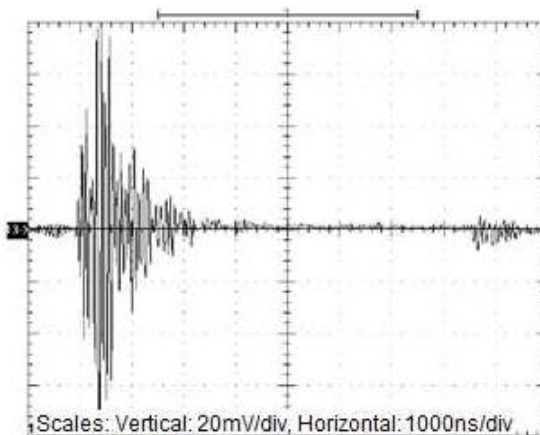
Evaluation of the HFCT for PD Measurement



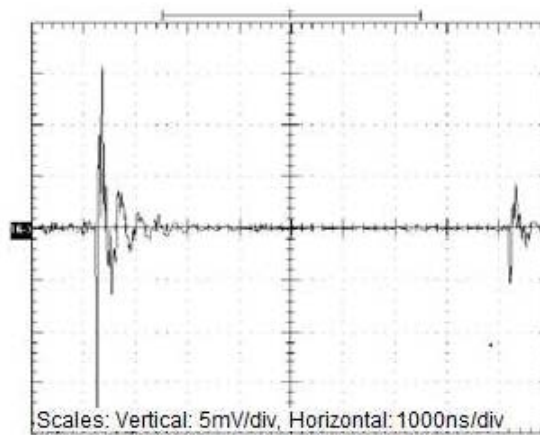
50 pC calibration signal detected
by the conventional method



50 pC calibration signal detected
by the HFCT number 3



PD signal detected by the
conventional method



PD signal detected by the
HFCT number 3

The **signature (waveform)** of the signal it's more important than amplitude.

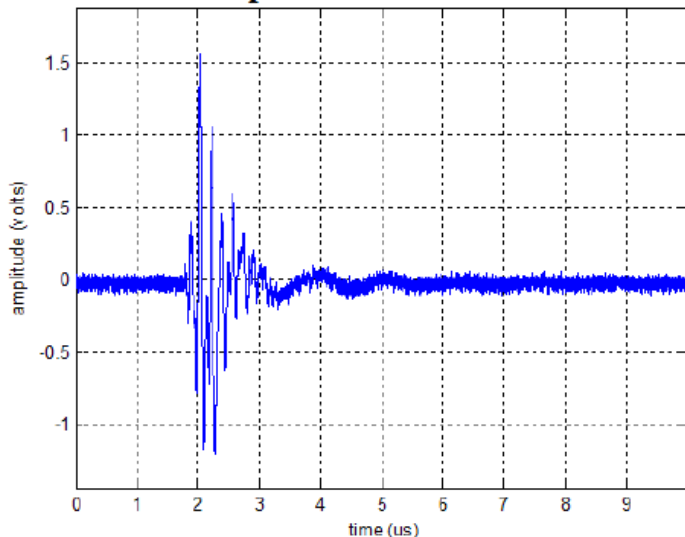
- The results obtained in the laboratory have shown that the measurement with HFCT can be performed satisfactorily on the evaluation of surge arresters operating condition, without significant loss of information or sensitivity to identify the phenomenon. In addition, the non-intervention in the supply of electrical energy is a significant factor.

- In September 2014 there were conducted field tests in a substation of the Brazilian electrical system for PD detection in surge arresters using HFCT as transducer.
- For the detection and recording of high frequency current pulses produced by PD it was used one HFCT, one 4-channel oscilloscope, an acquisition board, a notebook, a software to record the signals and the IMA-DP system (Instrumentation for Monitoring and Analysis of Partial Discharge) developed by CEPEL.

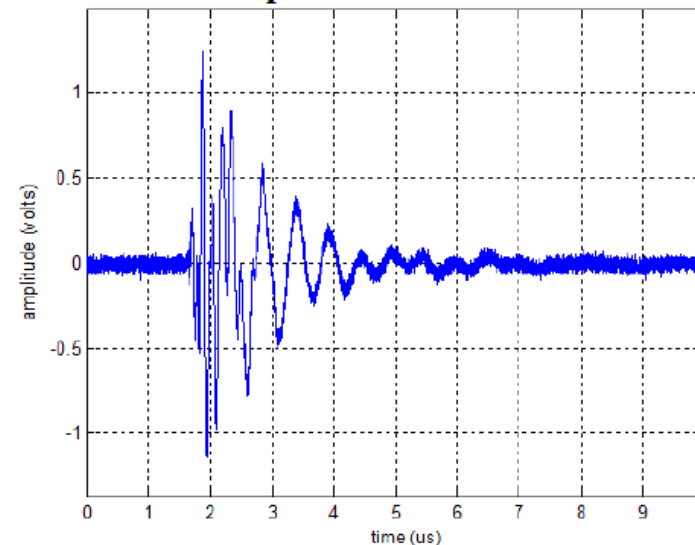
Results of tests on surge arresters of 230 kV

Localization	Phase A (mV _{max})	Phase B (mV _{max})	Phase C (mV _{max})
Line 1	180	270	220
Line 2	80	100	88
Line 3	80	160	110
Line 4	-700	1100	420
Line 5	150	230	130
Line 6	1600	-39000	1200
Reactor 1	10	95	120
Reactor 2	70	100	125
Reactor 3	350	130	130
Reactor 4	300	340	140
Transformer 1	112	240	120
Transformer 2	120	230	170
Capacitive bank 1	1500	820	330

phase A of line 6

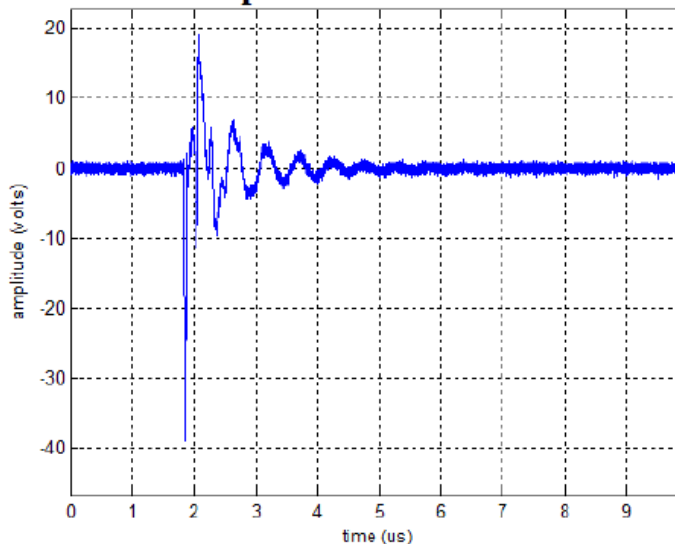


phase C of line 6



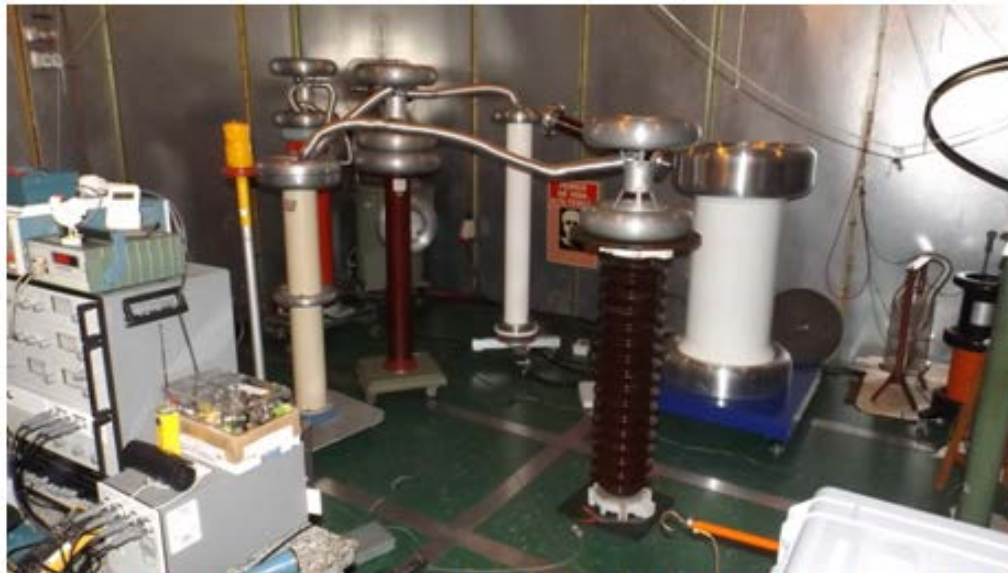
The test records indicate that the signal detected in phase B shows a rapid wave front, almost instantaneous decay and high frequency components.

phase B of line 6



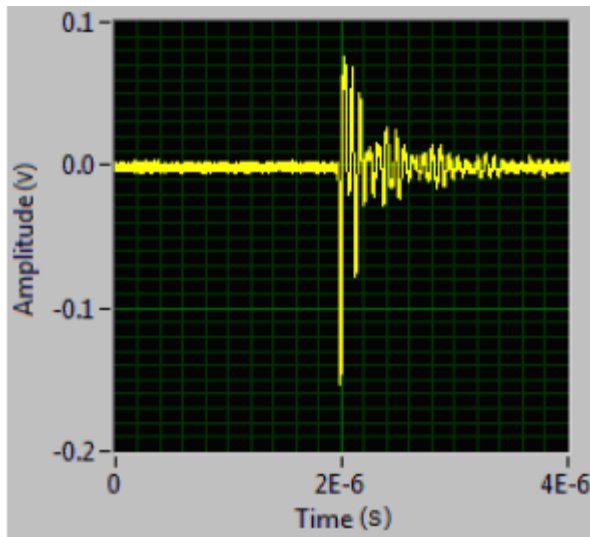
These indicators are derived from internal PD signals and put this equipment as an anomaly suspect.

- The next step was the removal of this equipment for tests in the laboratory of CEPEL. It was an important step for technical validation of this methodology, simple enough to be performed in the field.

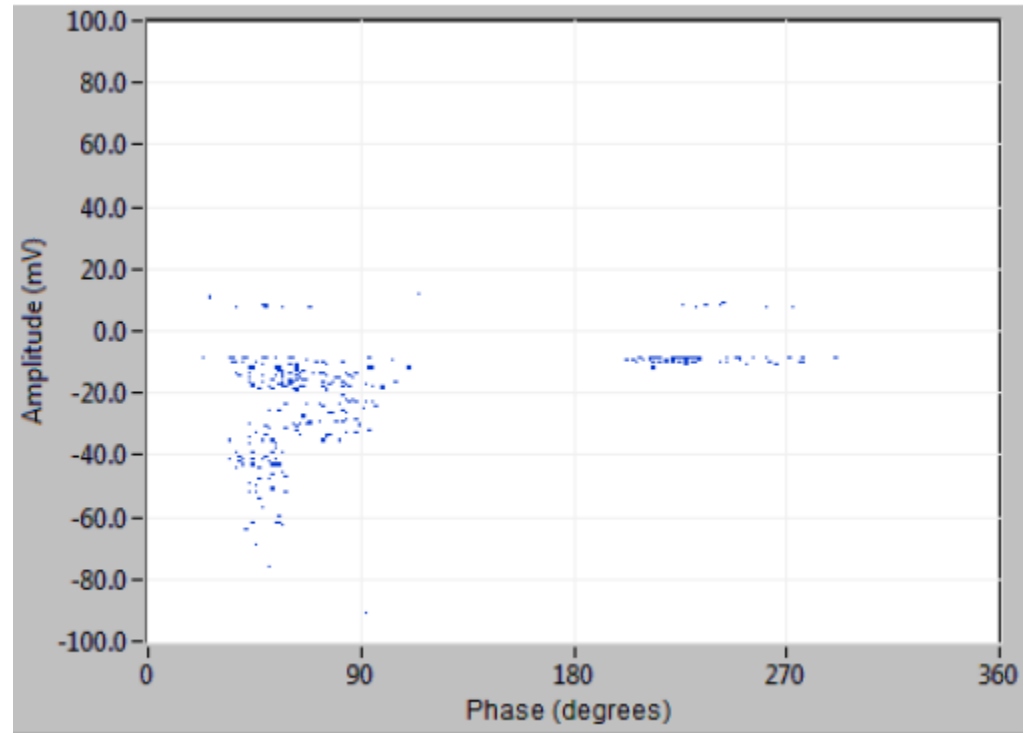


Arrangement in the laboratory for PD measurement on the surge arrester module

- The surge arrester in question has two modules that have been tested separately. One of the modules presented PD signals in order 200pC, well above the tolerable (10pC).



PD Signal acquired in time with HFCT via ground cable on the surge arrester module



PD signal recorded by the IMA-DP system

- There are significant similarities between the signals recorded in the field and recorded in the lab.

- Signals that have fast wave front and almost instantaneous decay are most probably related to internal PD signals.

- The main advantages of this technique include:
 - 1) The speed of execution of tests and evaluation of surge arrester in operation;
 - 2) Performing the test with energized equipment and in normal operation;
 - 3) Possibility to prevent costs caused by failures of surge arresters;
 - 4) Provides security to maintenance crews.

Thank you

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