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Calibration of Partial Discharge Measuring System by a Reference Square Wave

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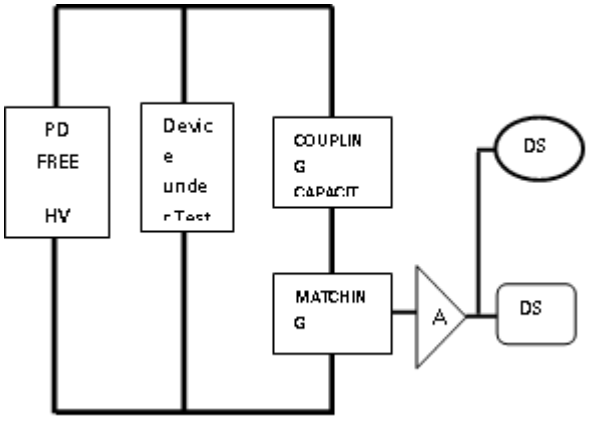
Abstract:
The Paper is about method of calibrating partial discharge measuring device. The measuring system captures the current impulses in the leads of the sample are then transformed into voltage impulses by rejecting any disturbances caused by high voltage source. These pulses are amplified and analysed in digital storage oscilloscope and PC Based analyzer. Before conducting partial discharge test with high voltage source, a pulse of known charge value is fed into the measuring circuit for calibration of the system and the scale factor of the PD measuring system is determined as per the Standard. This calibration assures the "apparent PD Magnitude" is measured correctly. The calibrator need to be calibrated periodically before the actual measurement. This operation is performed by applying a square wave of known amplitude to a series capacitor through matching impedance & amplifier circuit. A labview program is developed to measure the number of PD pulses obtained for different frequencies of input square wave. The results obtained characterize the partial discharge measuring system behavior.

Keywords: *Partial discharge, calibrator, matching impedance, amplifier*

I. INTRODUCTION

Partial. discharges (PD) is a localised electric discharges that partially bridge the insulation between the conductors of electrical equipments[3]. PD occurs due to insulation defects such as void in solid dielectric and bubble in liquid dielectric when the electric field is locally ahead of their breakdown strength. PD results in insulation failure. The detection is important to evaluate the state of the insulation, identify possible defects and prevent breakdown. Therefore, PD tests are acceptance tests for a lot of high voltage devices such as cables, bushings, transformers, rotating machines, etc.[4]Actual PD cannot be measured directly. Apparent charge, a pulse injected for short time for device under test would give same reading on the measuring instrument as the PD current itself. Measuring system response depends on the test circuit. The pd test is done by applying high voltage to the device under test and measuring apparent charge.The detection, measurement and location of the discharge are important parameters analysed in pd measurement [3]. The purpose of calibration is to assure that the "apparent PD magnitude" is measured correctly [4]. The calibration can be done in many ways but simplest & most reliable is to input a square wave. The output expected is a diracpulse[1]. For one square wave two pulses are expected on positive pulse above reference and one negative pulse below reference. For different frequencies of the input square wave signal, the out pulses also changes. Number of positive and negative peaks are counted using suitable digital analyser.

2. BLOCK DIAGRAM OF ACTUAL PD MEASURMENT SYSTEM



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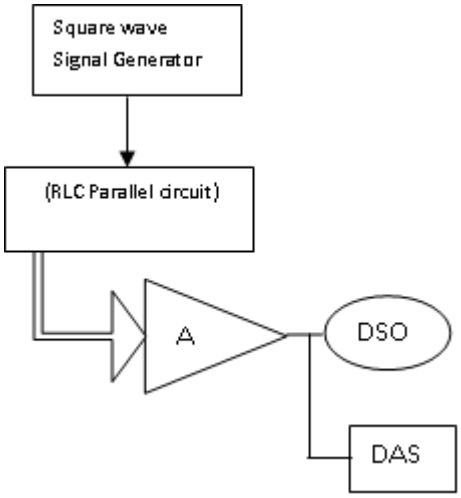
The figure represents the block diagram of complete partial discharge measurement system mainly consist of

- PD free HV source is a 100kV High voltage Transformer.
- Device under test is the sample affected by discharge.
- The coupling capacitor facilitates the passage of the high frequency current impulse and is a pd free, low inductance design (1000Pf capacity)
- Matching impedance is an RLC detector , the current impulse in the leads of the sample are transformed into voltage impulses with suitable bandwidth signal
- PD pulses are amplified using suitable amplifier circuit and observed in Digital Storage oscilloscope and PD data is acquired through PC Based digitizer and analysed.

The data acquisition and analysis system consists of a 1GHz Bandwidth, 2G samples/sec digitizer with a 8MB memory unit connected to an 16GB compatible computer. Using dedicated software, developed in NI labview platform the computer monitors the complete operation of the data acquisition system.

3. FINE TUNNING OR CALIBRATION OF PD MEASURING INSTRUMENT

To measure partial discharges (PD) according to Standard IEC 60270, calibrating the measuring device before the actual measurement is prescribed and necessary. For this matching impedance is supplied with square wave input through signal generator of known frequency with suitable amplifier gain setting, the output is amplified and output waveform is observed in Digital storage oscilloscope.



3.1 MATCHINGN IMPEDANCE:

The most common circuit used for partial discharge detection is based on a RLC network. The Fig. shows a schematic diagram of a typical RLC PD detection network. Measuring impedance is used for coupling of PD current pulses to convert it into voltage pulses for analysis. This circuit is implemented basically using a high voltage coupling capacitor terminated in measuring impedance. RLC circuit is similar to a high pass filtering effect. The primary behavior can be modeled as the second order response of an RLC network.

3.2 AMPLIFIER CIRCUIT: output of the RLC Network is applied to amplifier circuit designed as a Butterworth filter & Amplifier using duel JFET IC. The filters are used to suppress the noise and also reduce external interferences in PD measuring circuits.

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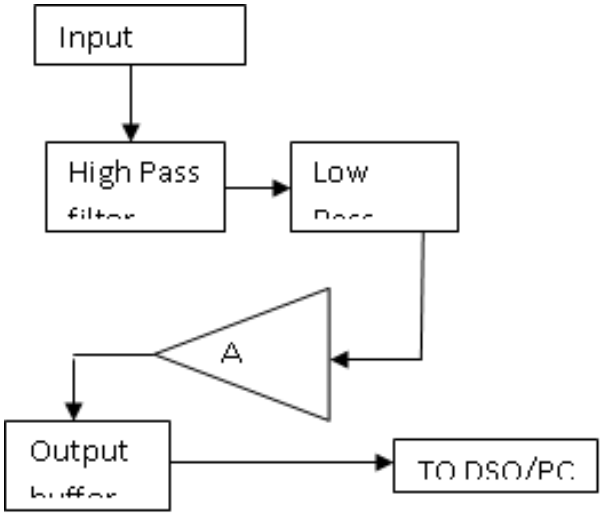
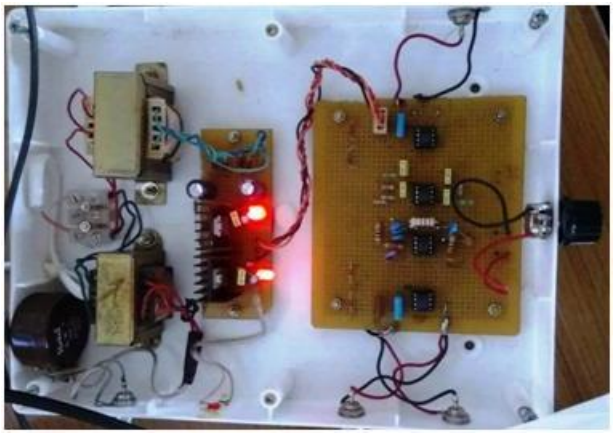


Table 4.1

Frequency	Approximate Pulse count expected
50Hz	100
1KHz	2000
2KHz	4000
3KHz	6000
4KHz	8000
5KHz	10000



3.3 PC BASED PD DATA ACQUISITION SYSTEM:

Partial discharge data is acquired to PC through national instrument PCI High speeddigitizer. The frontend customized GUI is developed using NI LabView software.

4. RESULTS AND DISCUSSION:

For calibration of the measuring circuit for PD, initially square wave is applied to calibration circuit output is observed in DSO and in PC based digitizer software.

4.1 Calculation:

For one cycle of square wave maximum pulse count is two

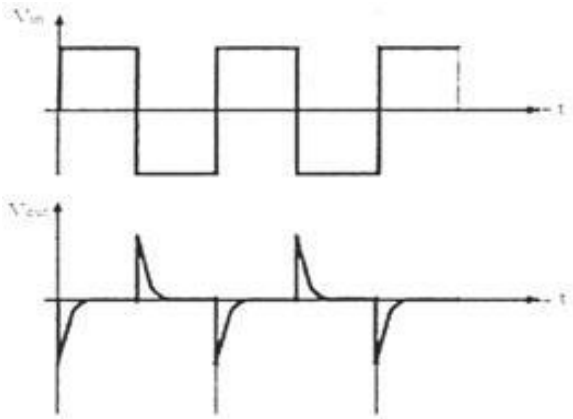


Fig. Input and Output waveforms for Square wave

Based on the square wave input applied, pulse count are calibrated by adjusting amplitude lower limit and time selection setting in the software adjustment. Peak amplitude of the signal is identified correctly, the results obtained are compared with as per the table 4.1

Input noise in the signal is reduced by grounding earthing terminal and conducting experiment in shielded room.

4.2 1KHz square wave input

Input: 2V, 1 KHz square wave applied through signal generator the pulse generated can be observed at positive and negative peaksNumber of Peaks observed is 2025

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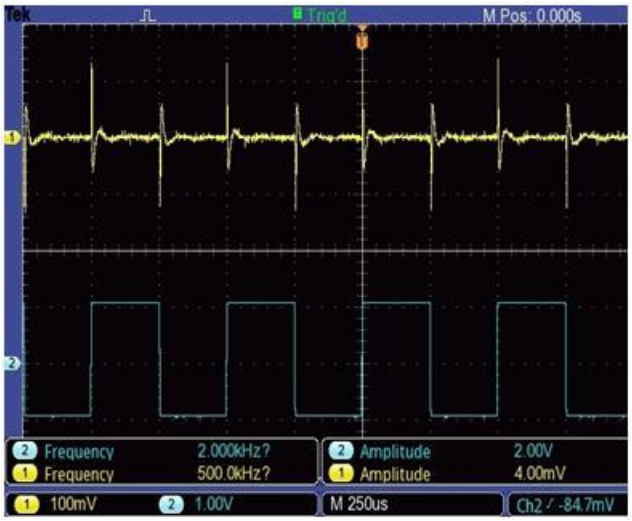
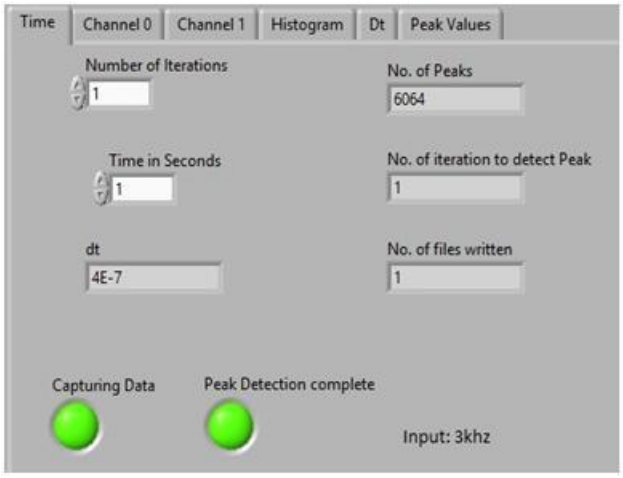


4.3 Input: 2 KHz input signa

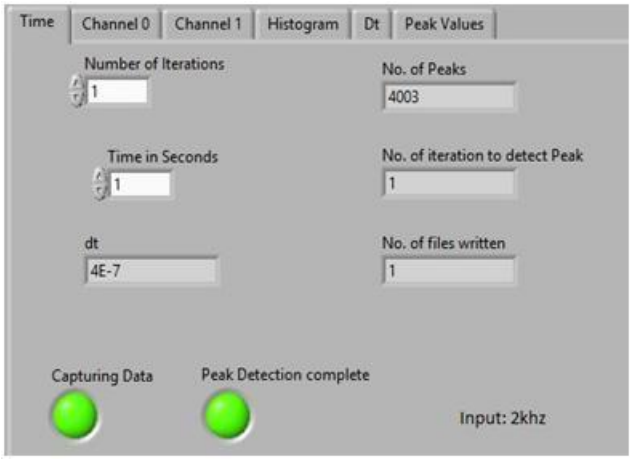
Observed output: 4003 peaks

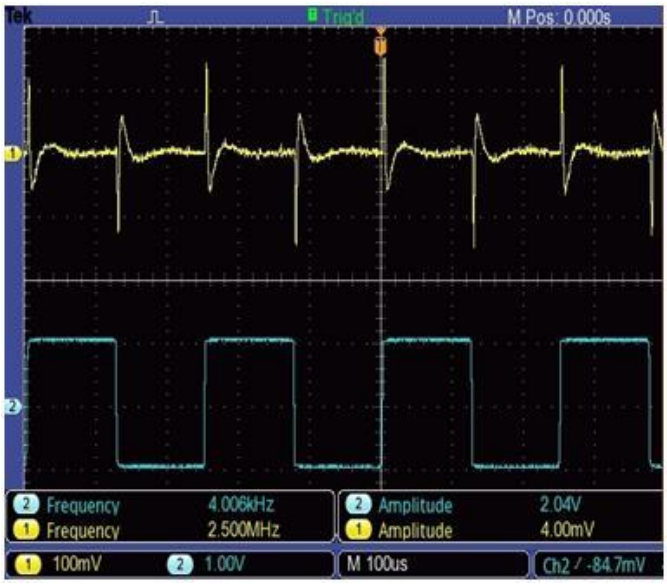
4.4 INPUT: 3KHZ INPUT SIGNAL

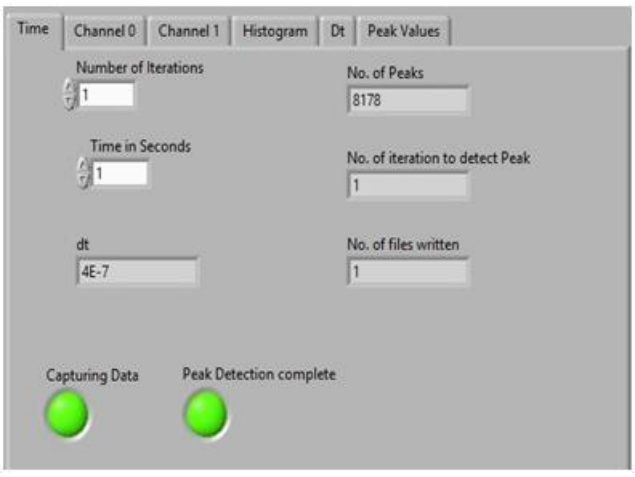


Output observed: 6064 peaks

4.5 Input : 4khz input signal







Output observed: 8178 peaks

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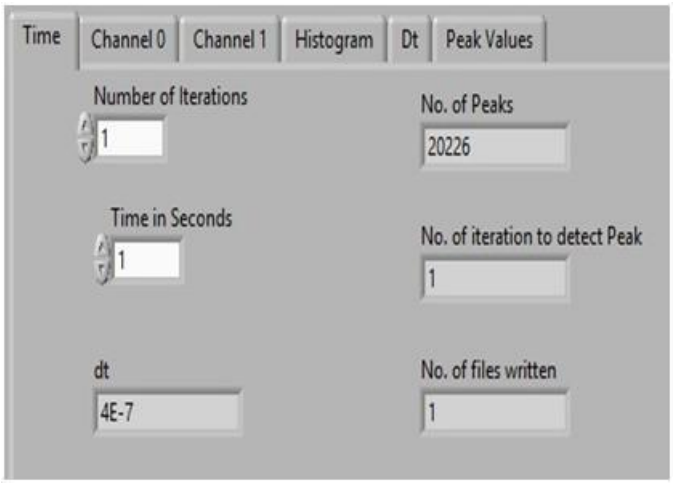
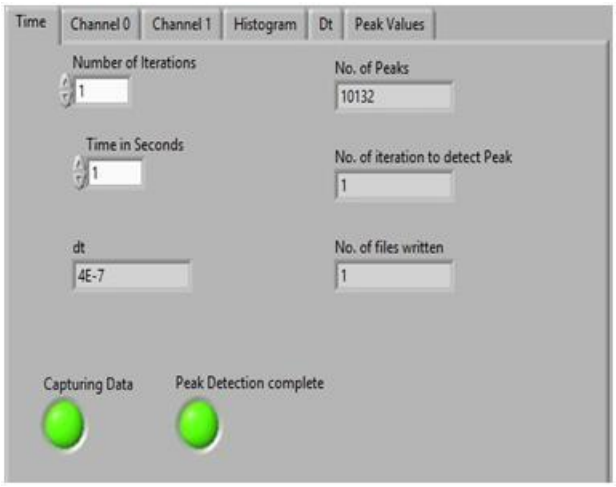
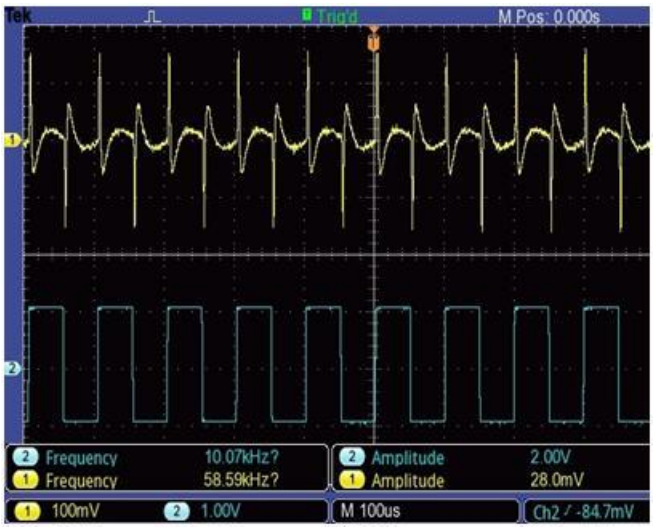
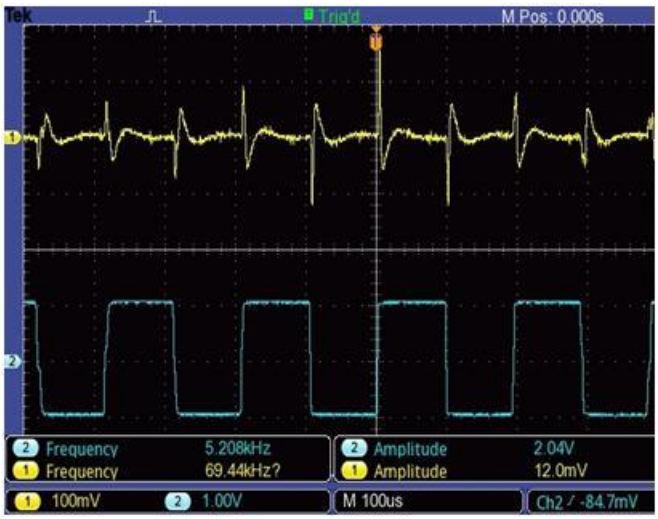






4.6 Input: 5khz input signal



Output observed: 10132 peaks

4.7 Input: 10khz

Output observed: 20226 peaks

6. Conclusion

In order to effectively analyze partial discharge characteristics in solid and liquid dielectrics the pd instruments matching impedance and amplifiers are need to calibrated as per the standards. The matching impedance is designed with LCR Circuit, amplifier is designed as Butterworth filter and gain is adjusted to required value. The output is observed in Digital storage oscilloscope and also data is collected to PC using high speed digitizer. The application is developed using NI labview software, which communicates with digitizer and shows number of pulse count. Results shown are matching almost required value. Thus the designed setup can be used for actual pd measurement by fine tuning the gain in amplifier and adjusting reference scale factor in NI labview setup.

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