Improved Hybrid Detection Experimental Configuration of Partial Discharge in Gas Insulated Switchgear

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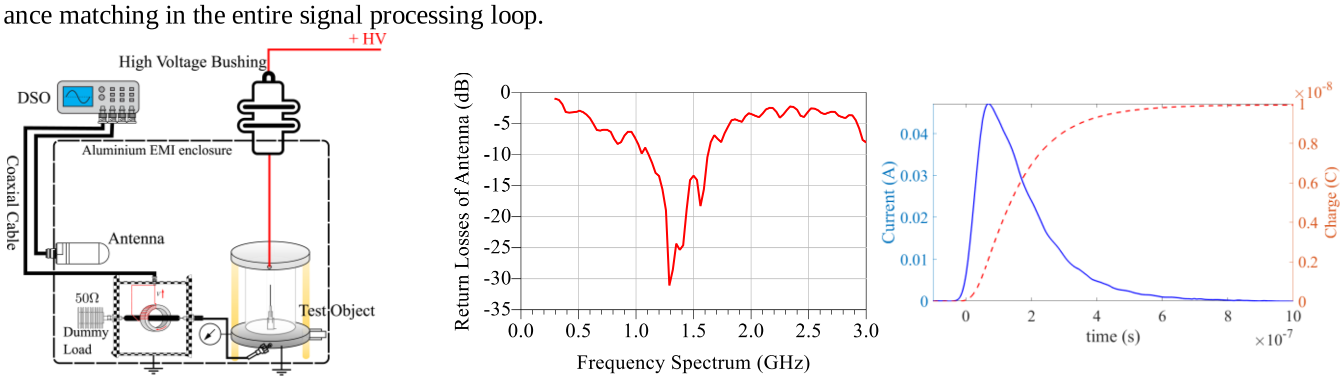
***Abstract*— This paper establishes a simultaneous discharge detection experiment setup based on different physical peculiarities of the partial discharge phenomenon with two types of different coupling devices (high frequency current transformer and ultra high frequency antenna) to be ready for examining gaseous insulation degradation under AC or DC voltage. Combining the radio frequency antenna and conventional IEC-60270 devices in practical research requires the validation of an updated setup. Given the sensitivity of the current transformer and ultra high frequency antenna to capacitive noise, optimised partial discharge current transmission with a higher signal-to-noise ratio will be achieved by utilising faraday enclosures around coupling devices. To replicate several idealised partial discharge impulses and assess the effectiveness in noise reduction, initial calibration was performed on free-moving particles simulating defects in partial gas insulated switchgear. Additionally, a network analyser was used to determine the ultra-high frequency antenna's return losses to illustrate its resonant frequency. These results confirm the advantages of increasing signal-to-noise ratio in novel configurations and verify the properties of an antenna design in radio frequency partial discharge detection methods, while applying to hybrid detection is helpfully assisting to identify incipient defects with more flexible and reliable methodology to accommodate health diagnostics based on discharge monitoring in gas insulated switchgear.**

Background & Main Results

Partial Discharge (PD) typically occurs in regions of high electrical stress that exists around impurities inside the Gas Insulated Switchgear (GIS) and can become a particular breakdown risk. However, one significant difficulty in replicating the defect conditions of GIS in experiments is the environmental noise with High Frequency Current Transformers (HFCTs) and Ultra High Frequency (UHF) antennas being sensitive to external interference. Simultaneous detection involves two wide bandwidth PD detection methods but is complicated by the noise ratio in different frequency spectra. To detect low noise and accurate signals from PD, reducing Electromagnetic Interference (EMI) and calibration of conventional method mentioned in IEC 60270 [1] are crucial. It is also essential to extract key metrics and statistical features from the detection results (inductive voltage from HFCTs and UHF energy generated from PD), which helps identify the severity of a physical defect within the dielectric insulation. More critically in condition monitoring aspects, UHF methods need to guarantee the sensitivity of the antenna and its input reflection coefficient should lie in the 300MHz – 3GHz range to minimise the potential electromagnetic energy signal losses in UHF bandwidth. In our proposed test configuration, the coupling current transformer and UHF antenna are shielded in a faraday cage to reduce environmental noise. The performance of the antenna was benchmarked using 9 kHz – 6 GHz Vector Network Analyser (VNA). Meanwhile, the maximum power transfer was achieved by applying 50Ω impedance matching in the entire signal processing loop.



(a) (b) (c)

Fig. 1 (a) Entire experimental setup of hybrid PD detection (b) the S11 return losses results of monopole antenna (c) 10 nC impulse calibration results of updated HFCT device and test object configuration

Conclusions

Fig. 1 (a) represents the configuration of the whole setup for calibration and future testing (b) verifies the antenna could receive maximum power in 1.290 GHz, which is approximately close the centre frequency inside the UHF range and (c) is the initial 10pC impulse injection calibration results of the HFCT. The cumulative integral of current (V/I ratio: 5:1 in oscilloscope) gives the final charge received. This result is very close to the 10nC injection from Haefely KAL 9511 calibrator. These initial results validate the sensitivity and measurement accuracy of the new simultaneous measurement setup giving confidence in its performance for future PD detection in researching insulation integrity with hybrid measurement methods.

References

[1] IEC 60270, High-voltage test techniques: partial discharge measurements. International Electrotechnical Commission, 2000.