The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

WORK PACKAGE 4 Validation of a calibration procedure for PD analysers used for HVDC insulation diagnosis.

PARTICIPATION IN TASK 4.1 New Synthetic PD Calibrator to qualify PD analysers used for insulation diagnosis of HVDC and HVAC cable systems

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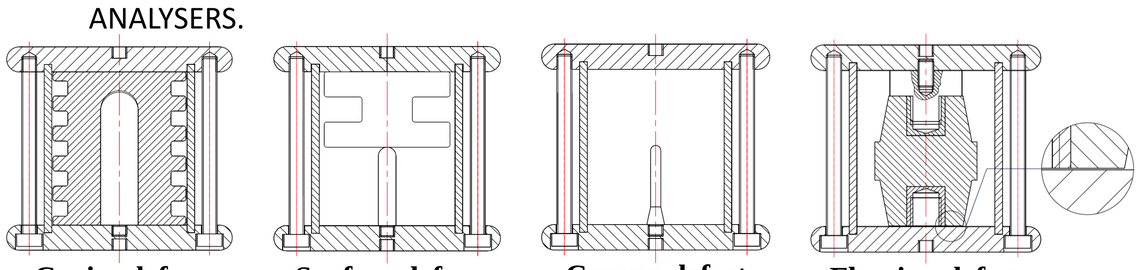
Work package leaded by LCOE-FFII.

Aim of the work package. **VALIDATE A CALIBRATION PROCEDURE FOR PD ANALYSERS USED IN HVDC INSULATION DIAGNOSIS USING AN ADJUSTABLE SYNTHETIC REFERENCE PD GENERATOR (TASK 4.1)** AND PD CHARGE EVALUATION IN HVDC GIS USING MAGNETIC SENSORS (TASK 4.2).

IN UPM FOUR INSULATION DEFECTS HAVE BEEN DESIGNED, MANUFACTURED, TESTED AND AGED FOR THE FOLLOWING REQUIREMENTS

- LARGE AMOUNTS OF DATA ARE NEEDED TO IDENTIFY PD PATTERNS ASSOCIATED WITH THE REAL INSULATION DEFECTS IN HVDC ELECTRICAL SYSTEMS.
- THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE TOOLS FOR INSULATION DEFECTS RECOGNITION BASED ON REFERENCE PD PATTERS AND HISTOGRAMS IS AN IMPORTANT TASK TO COMPLETE AND IMPROVE THE DIAGNOSIS PROCESSES. LARGE AMOUNTS OF HVDC PD TIME SERIES ARE REQUIRED FOR THE TRAINING AND TESTING PROCESSES OF AN ARTIFICIAL INTELLIGENCE TOOL TO BE DEVELOPED IN THE FRAME OF THIS TASK.
- THE DEVELOPED SYNTHETIC PD SOURCE GENERATOR DEVELOPED IN THIS RESEACH PROJECT REQUIRES A WIDE DATABASE OF PD PULSE TRAINS OF REAL DEFECTS TO EXTEND AND VALIDATE THE PD PROCEDURE FOR QUALIFYING PD ANALYSERS.

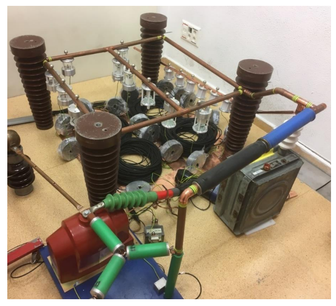


Cavity defect | **Surface defect** | **Corona defect** | **Floating defect**

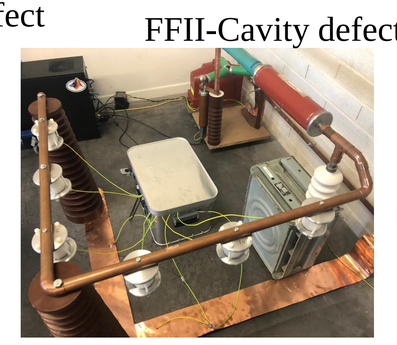
A total of **24 test cells** (6 per defect) 3 for + polarity and 3 for **-** polarity

Experimental setups

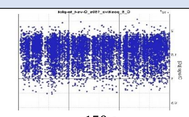
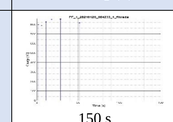
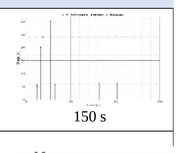
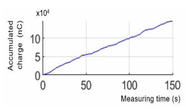
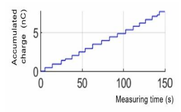
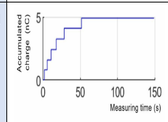
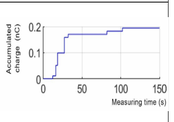
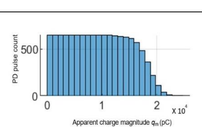
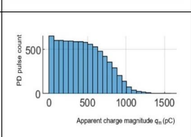
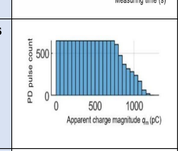
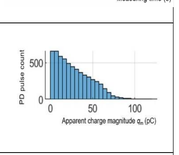
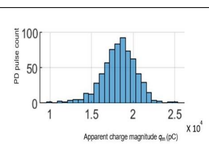
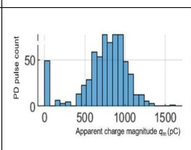
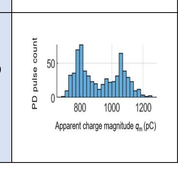
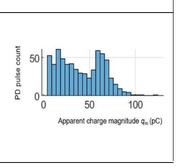
UPM- Floating, corona and surface defect

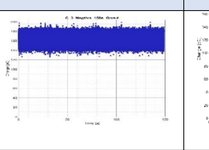
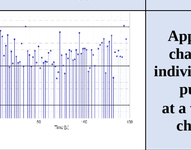
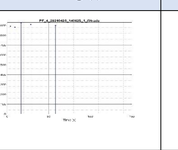
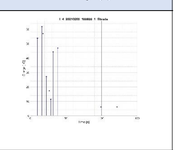
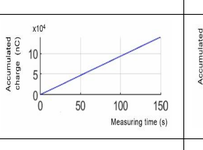
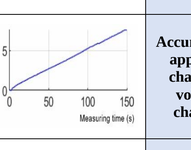
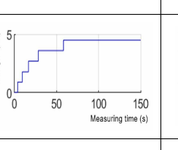
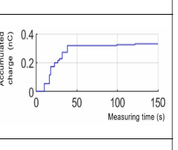
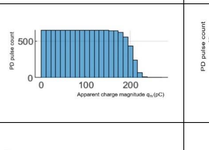
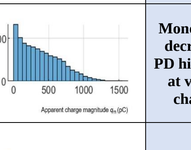
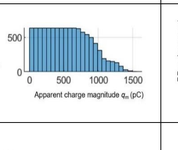
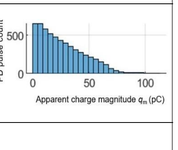
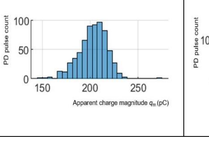
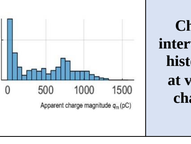
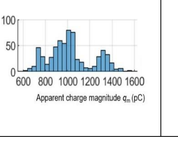
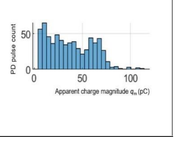


FFII-Cavity defect



PARTIAL DISCHARGE ANALYSIS

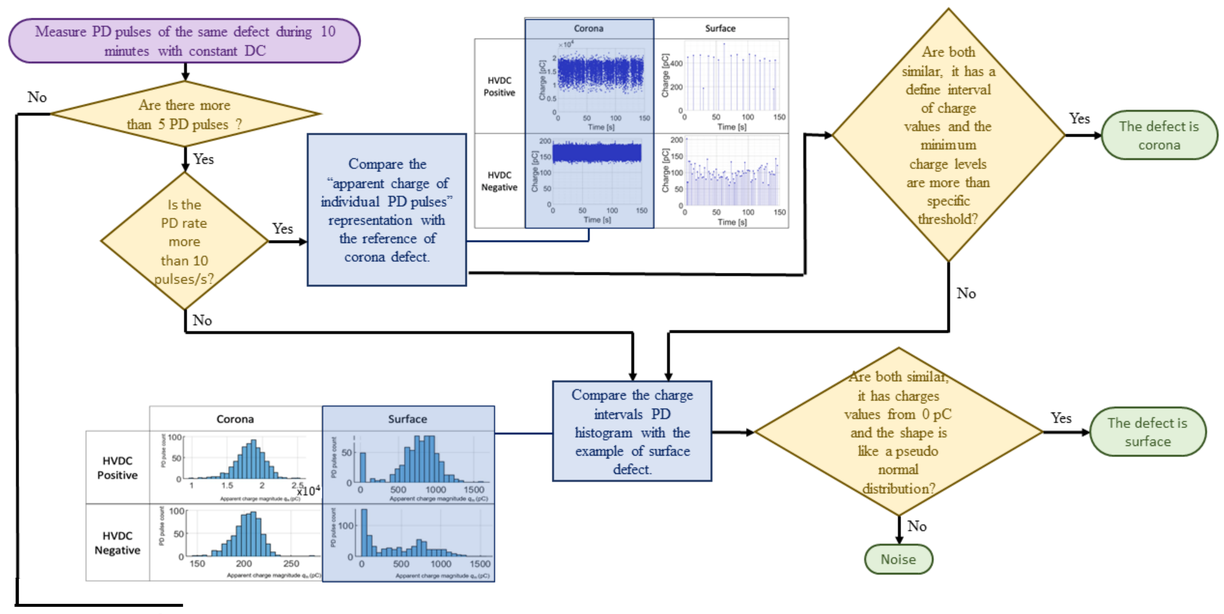
For constant direct voltage			For direct voltage changes $u(t)= Uo \cdot (1-e^{-t/\tau})$; Uo=30 kV; τ=16 s		
PD Pattern	**Corona (+)**	**Surface (+)**	**PD Pattern**	**Floating (+)**	**Cavity (+)**
Apparent charge of individual PD pulses 150 s	 150 s	 150 s	**Apparent charge of individual PD pulses at a voltage change**	 150 s	 150 s
Accumulated apparent charge at constant voltage.			**Accumulated apparent charge at a voltage change**		
Monotonous decreasing PD histogram m=650 p			**Monotonous decreasing PD histogram at voltage changes**		
Charge intervals PD histogram m=650 p			**Charge intervals PD histogram at voltage changes**		

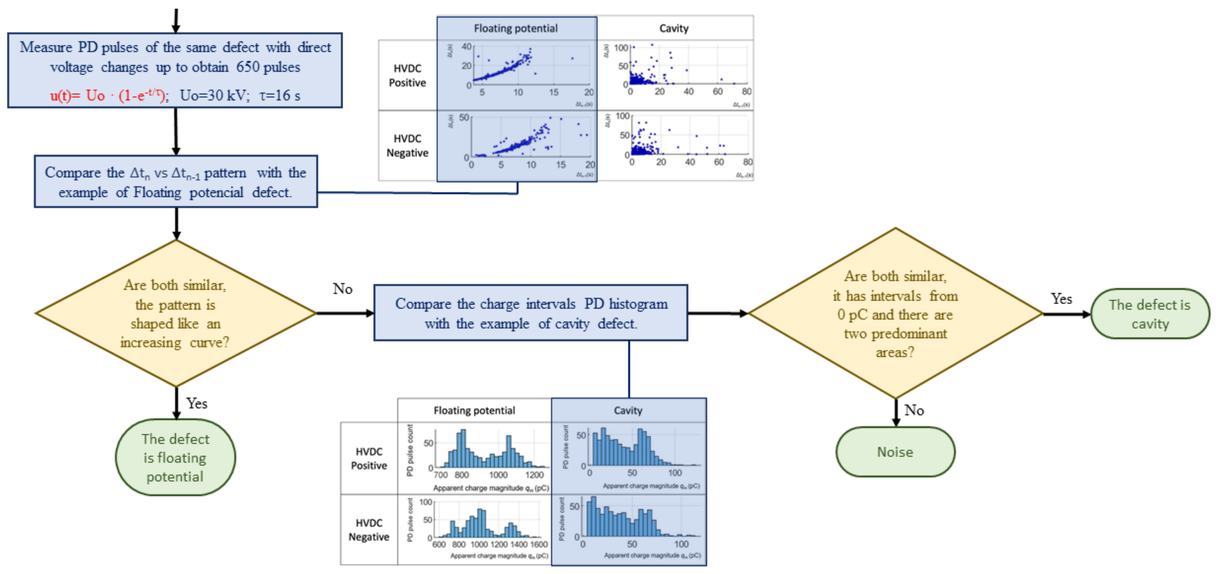
Constant direct voltage			Changing direct voltage $u(t)= Uo \cdot (1-e^{-t/\tau})$; Uo=30 kV; τ=16 s		
PD Pattern	**Corona (-)**	**Surface (-)**	**PD Pattern**	**Floating (-)**	**Cavity (-)**
Apparent charge of individual PD pulses 150 s			**Apparent charge of individual PD pulses at a voltage change**		
Accumulated apparent charge 150 s			**Accumulated apparent charge at voltage changes**		
Monotonous decreasing PD histogram m=650 p			**Monotonous decreasing PD histogram at voltage changes**		
Charge intervals PD histogram m=650 p			**Charge intervals PD histogram at voltage changes**		

PARTIAL DISCHARGE TIME SERIES ANALYSED

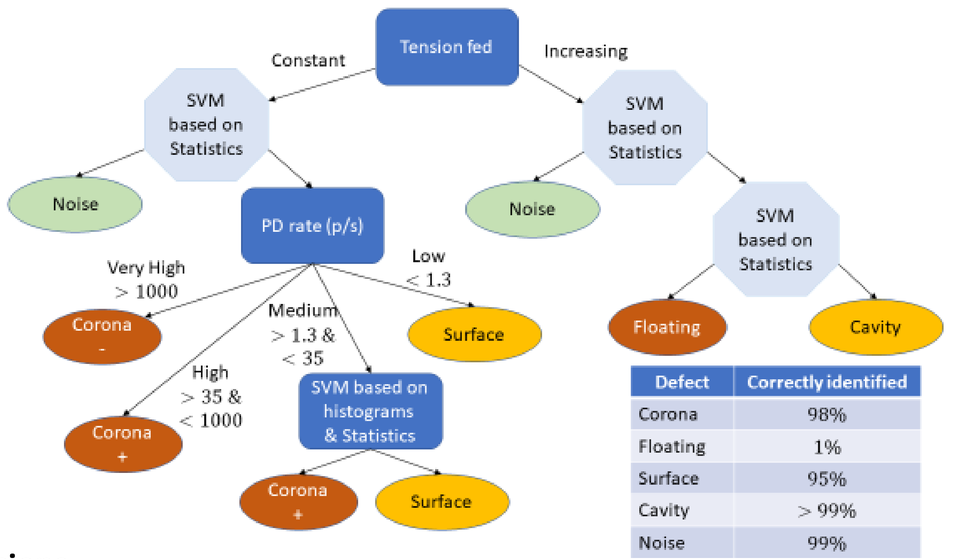
Defect	Measured trains	PD trains considered	Reason for the rejection
Corona +	≈ 700	657	Severe noise
Corona -	≈ 700	609	
Cavity +	≈ 700	538	
Cavity -	≈ 700	569	
Surface +	≈ 700	427	Severe noise/no PD activity
Surface -	≈ 700	343	
Floating Potential +	≈ 700	371	
Floating Potential -	≈ 700	194	

COMPARISON OF DEFECTS AND FLOWCHART FOR THE DEFECT DETERMINATION





ARTIFICIAL INTELLIGENCE TOOL FOR HVDC INSULATION DEFECTS RECOGNITION AND PARTICIPATION IN THE ROUND ROBIN TESTS



Defect	Correctly identified
Corona	98%
Floating	1%
Surface	95%
Cavity	> 99%
Noise	99%

Conclusions

A reference data base of partial discharges trains generated in test cells with characteristic insulation defects under HVDC stress is available for research purposes.

The generated, collected and analysed data have been useful for the identification of reference PD patterns and histograms associated with insulation defects in HVDC, for the development of an artificial intelligence tool used for insulation defects recognition and for the development of a synthetic PD generator used to perform and validate a defined PD procedure for qualifying PD analysers. Furthermore, the results obtained and the artificial intelligence tool developed have been useful for the realization of the round robin tests carried out for the qualification of PD analysers.