Detection and localization of Partial Discharge in High voltage power cable Using Damped AC Signal

M. Tech. Project Presentation- Mid-Semester

Department of Electrical Engineering

Under the supervision of: Prof. C .C .Reddy

Presented by : AMIT KUMAR

Entry no: 2023EEM1039

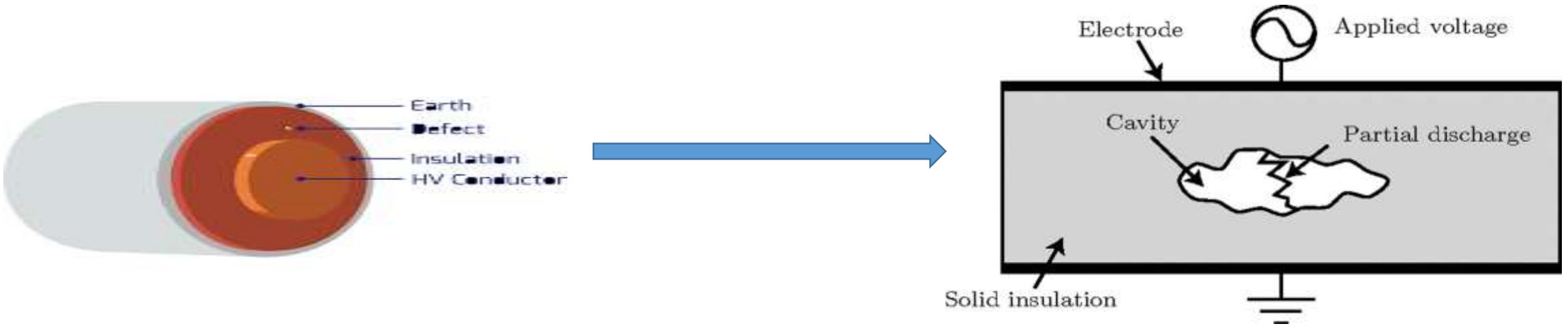
Outline

- Introduction
- Motivation
- Literature Survey
- Work in progress
- Research Gap and Timeline
- References

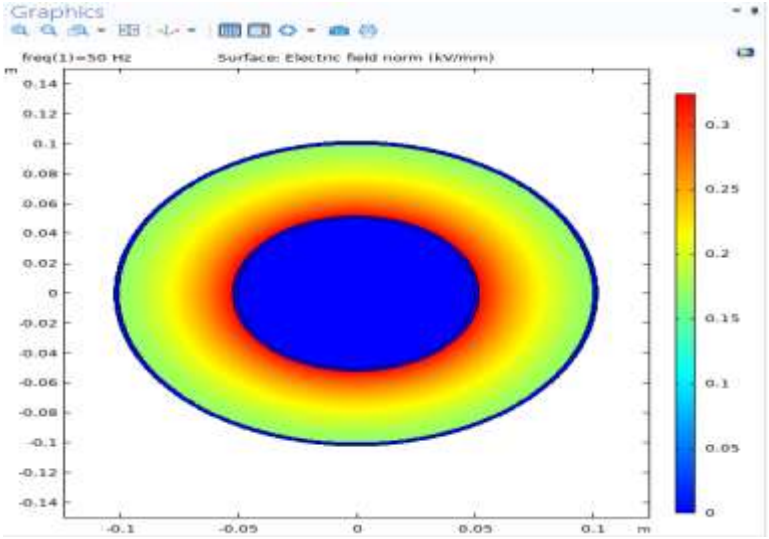
Introduction

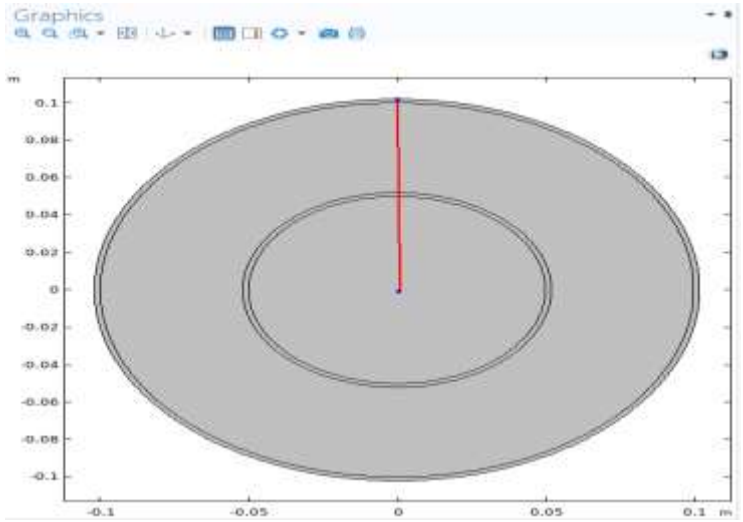
What is Partial discharge?

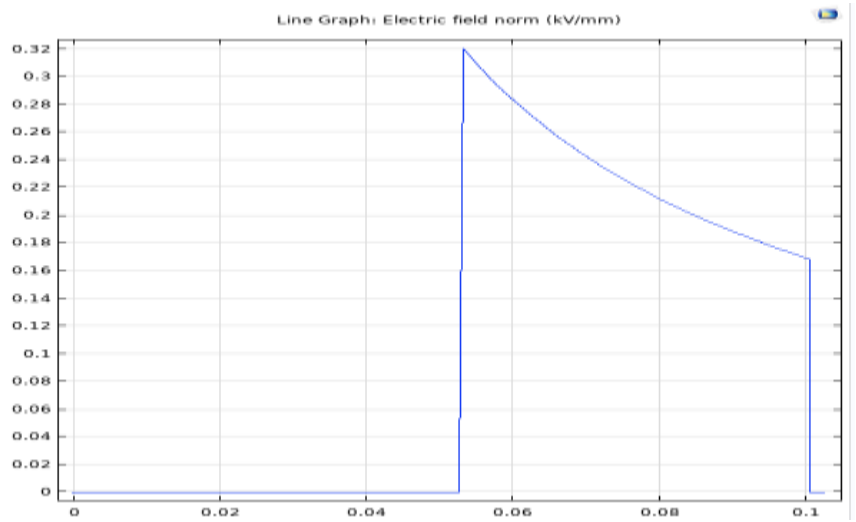
- Partial discharge (PD) is **a localized dielectric breakdown** (which does not completely bridge the space between the two electrodes)
- PDs are in general a consequence of local electrical stress concentration in the insulation or on the surface of insulation
- Generally, such discharges appear as pulses having duration less than 1 uS.

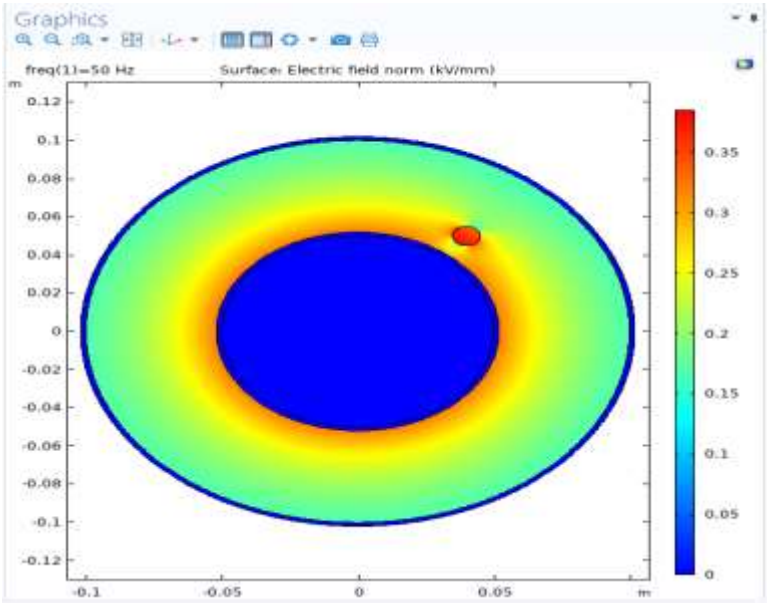


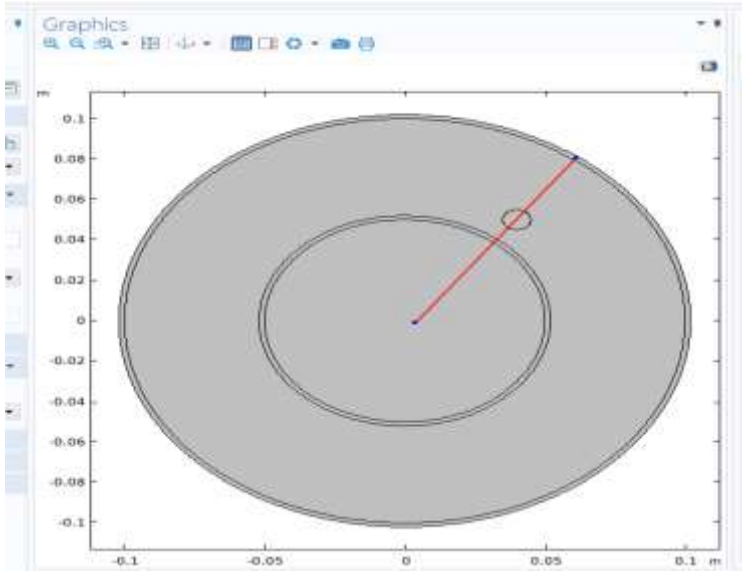
Effect of void on electric field variation in underground cable:-

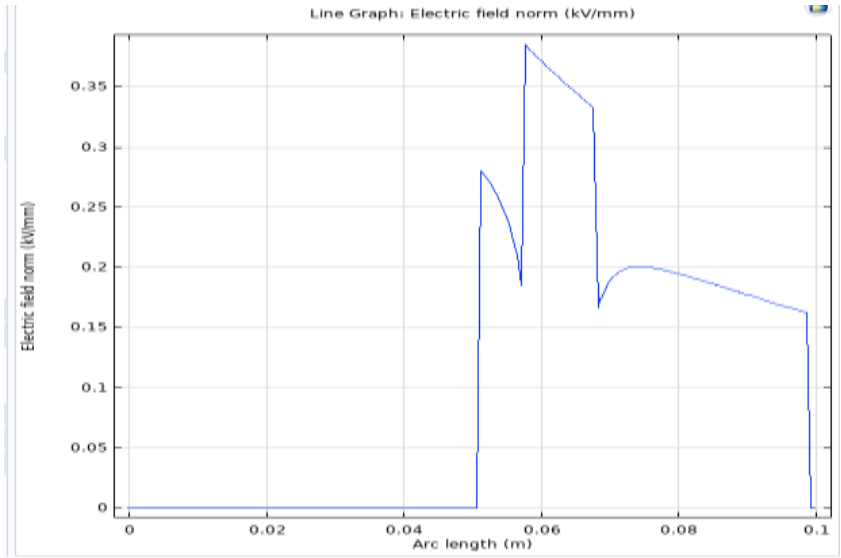












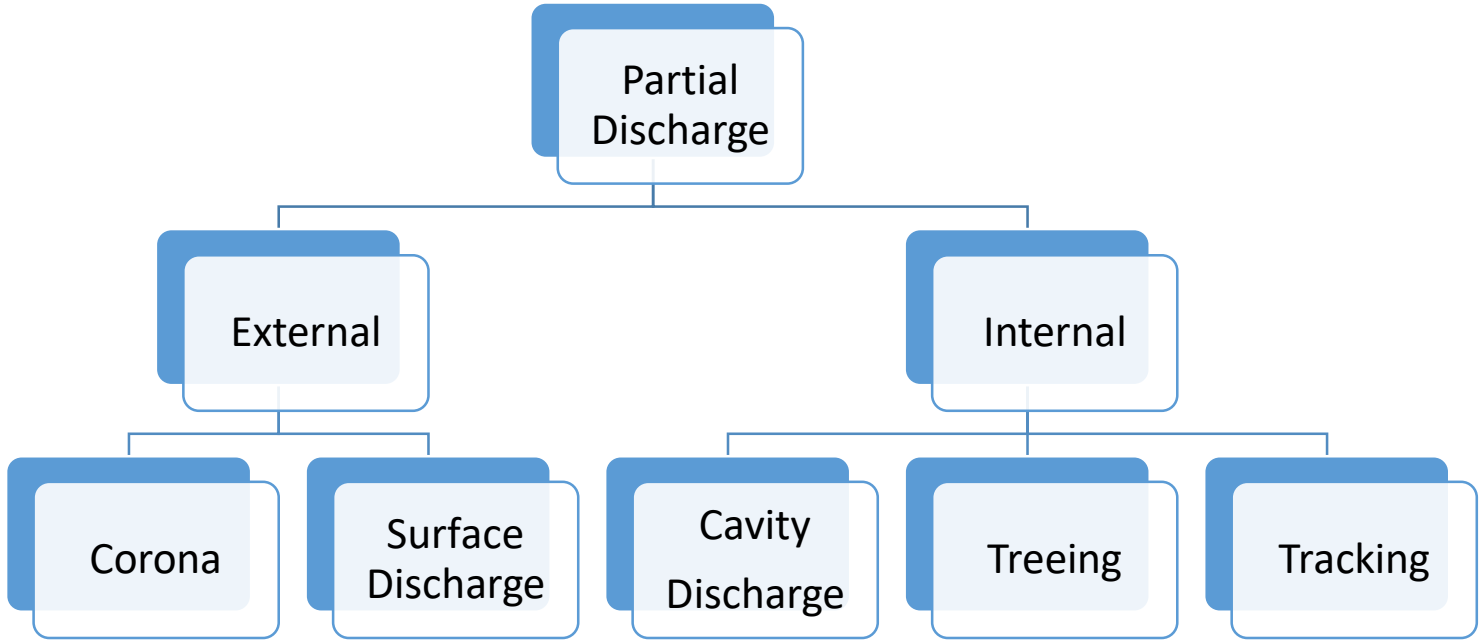
Why detection and localization of PD is important?

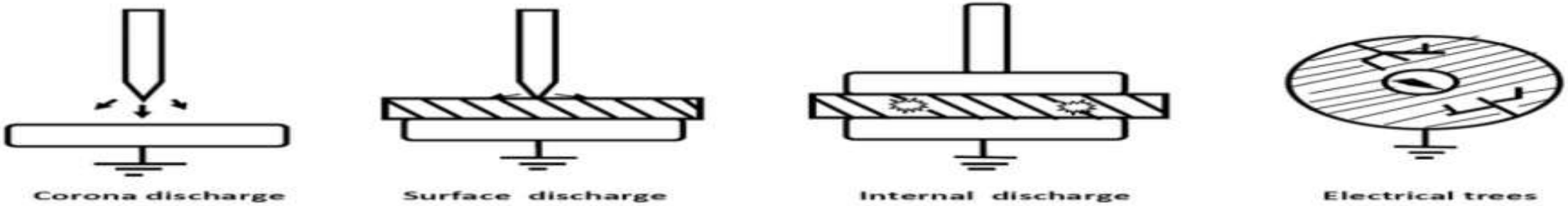
- The detection and continuous assessment of PD information may give significant insight into the state of the insulation.
- Polymeric insulating materials such as cross-linked polyethylene (XLPE) have been reported to completely degrade within a few days following the emergence of PD

(If not located , it will ultimately cause its failure(collapse of equipment)

- Cost of equipment (so high capital investment).
- In case of cable(location of faulty parts, taking it out and replacing it will cause significant loss of capital, time, manpower involvement , loss of supply).

Types of partial discharges?

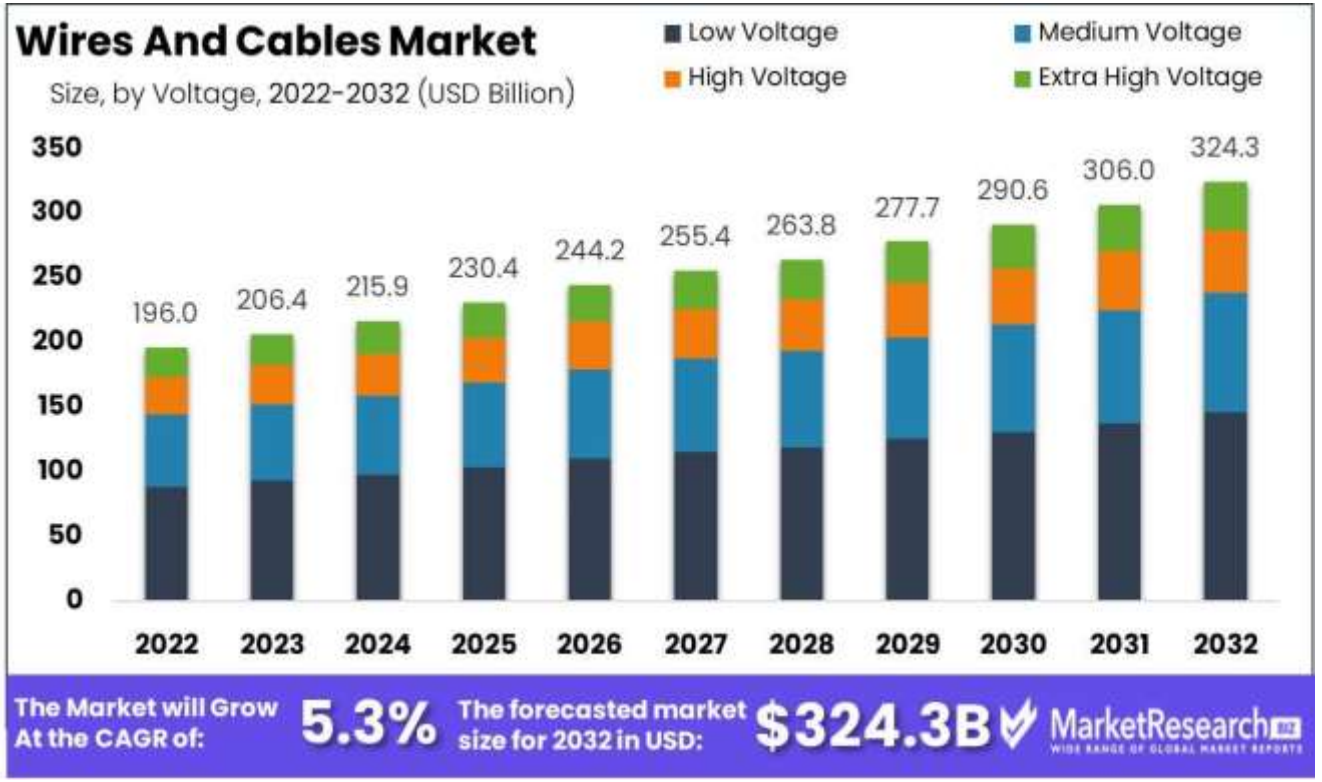




Motivation:

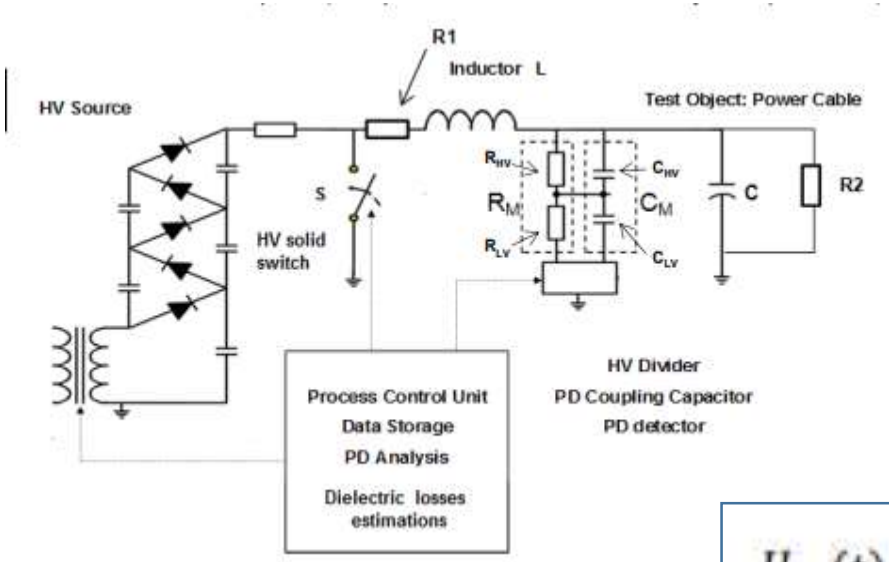
“ Power cable is the future for Power Transport”

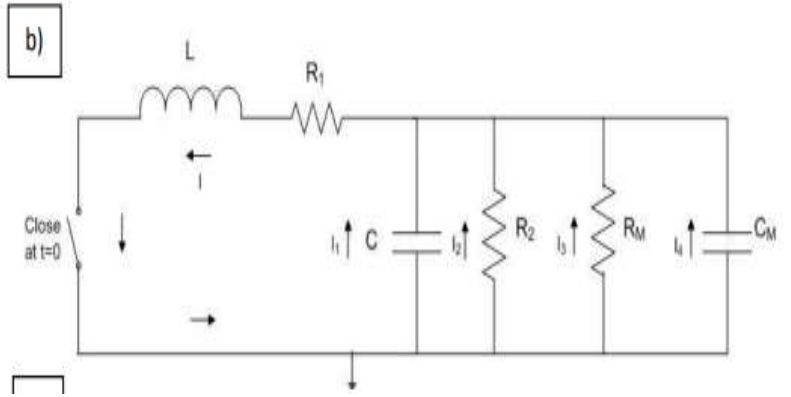
- Smart city projects
- India’s goal of 30 GW of offshore wind power by 2030
- Rapid urbanization
- Modernization of railways
- Modernization of power grid ,growth in renewable energy generation.



Literature Survey

Paper:1 P Cichecki,” Testing and Diagnosis of High Voltage and Extra High Voltage Power Cables with Damped AC Voltages”, DOI: https://doi.org/10.4233/uuid:f50c2129-6771-468b-aa3c-7c1fdac4e425



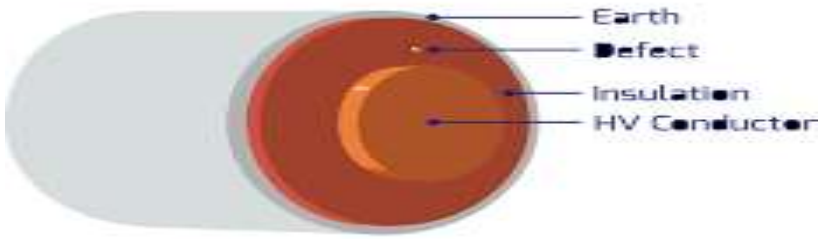


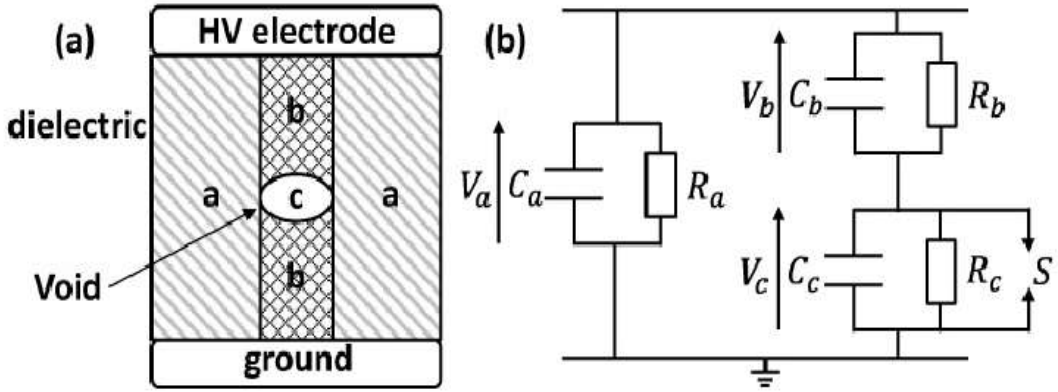
$$U_{C0}(t) = U_{C0}(0)e^{-\alpha t}\cos(\omega_0 t)$$

$$\alpha = \frac{R_1}{L} = \frac{1}{R_x C_x}$$

$$\omega_0 = \sqrt{\frac{1}{LC_x}}$$

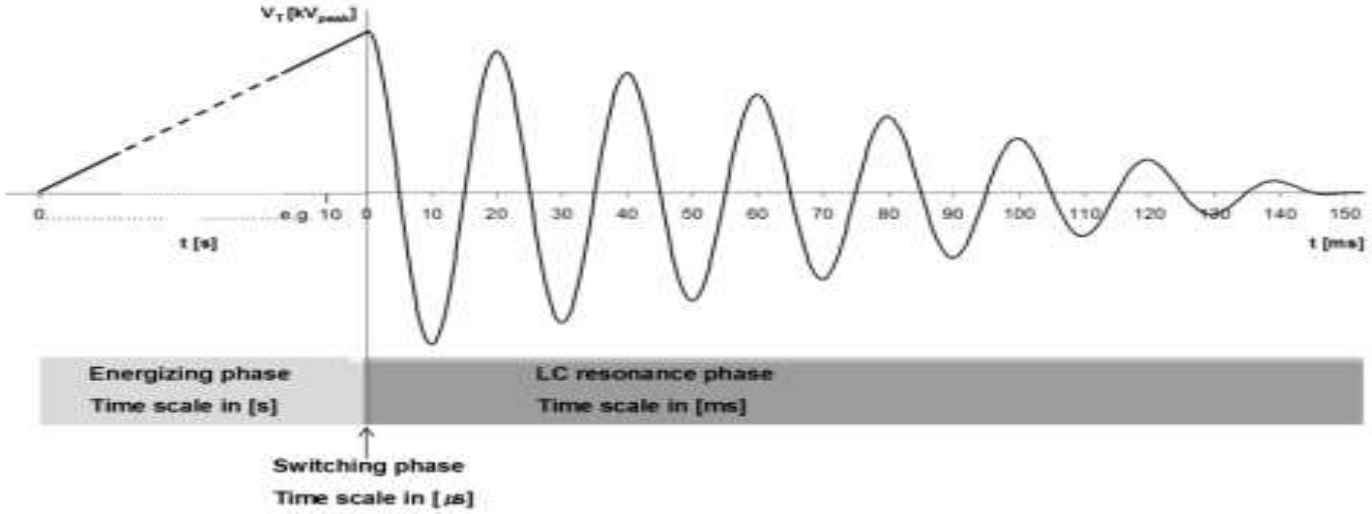
Modelling of void





Phases during DAC testing phase:

- Energizing phase
- Switching phase
- LC resonance phase



Paper:2

M. Wild, S. Tenbohlen, E. Gulski and R. Jongen, "Basic aspects of partial discharge on-site testing of long length transmission power cables," in *IEEE Transactions on Dielectrics and Electrical Insulation*, vol. 24, no. 2, pp. 1077-1087, April 2017, doi: 10.1109/TDEI.2017.006311

- Accordingly to IEEE 400, IEC 60840 and IEC 62067 for transmission power cables (110 kV and higher voltage ratings) the accepted testing methods are:

1) 50/60 Hz AC transformer test
2) 20–300 Hz AC resonant test
3) 20–500 Hz Damped AC test

- For example, a 25 km long XLPE insulated transmission power cable with a capacitance of 0.205 µF/km has a total capacitance of 5.1 µF.

According to the test after installation acc. IEC 62067 and IEEE 400.4, the cable needs to be tested with a voltage up to 180 kV.

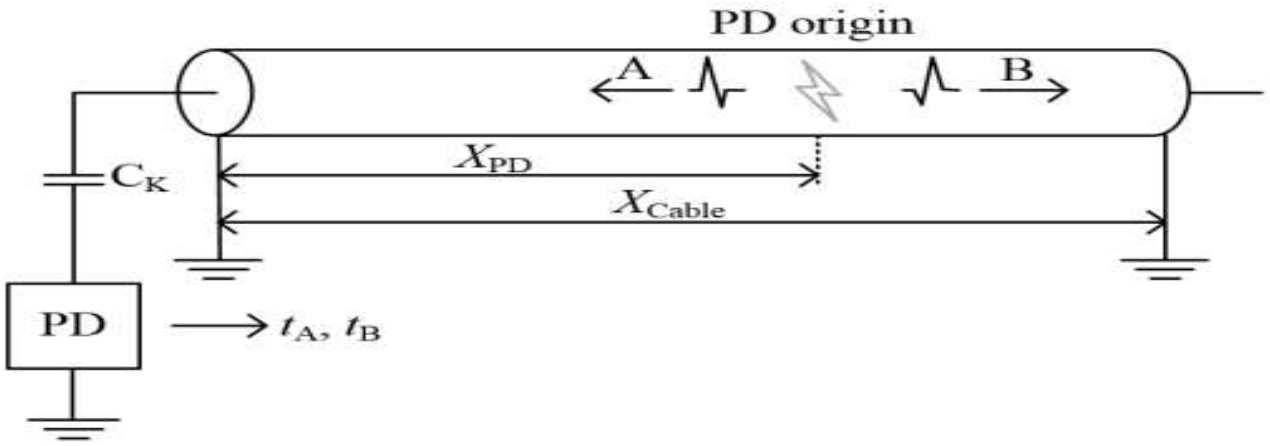
AC Transformer Test

To test the cable from the above example at 50 Hz, with a classical 50 Hz transformer, a power of up to 52 MVA is needed

	AC resonant test	Damped AC test
Test voltage level[kvrms}	180	180
Test Capacitance[uF]	5.1	5.1
Approx. test frequency	25	30
Approx. input power demant[kVA]	400	15
Approx. total system weight[kg]	70 tons	2 tons
Approx. transport volume[m3]	150	10
Approx. Footprint of test setup[m2]	120	20
Means of transport	2-3 trucks (excluding generator)	Small truck
PD detection application	Local detection at the sensor position	Overall detection over the complete cable length
PD localization	Terminations and cross-bonding joints only	Ternibnations, all joint types and cable insulation

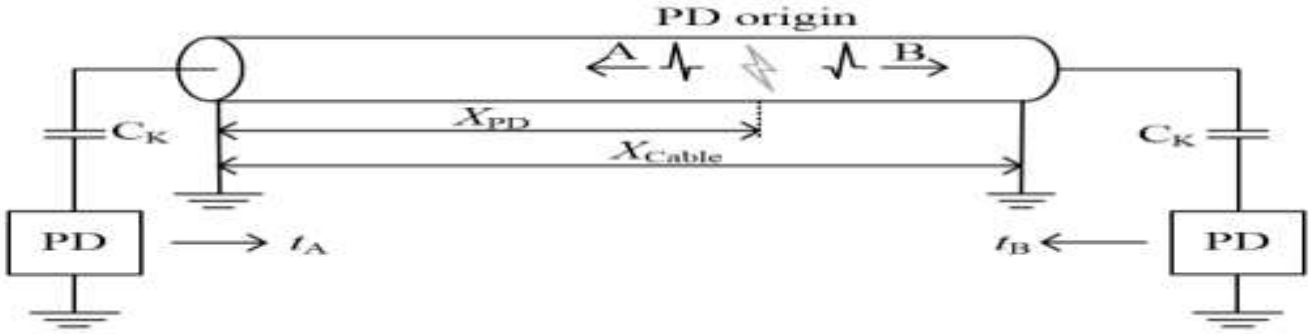
Basic Aspects of Sensitive Partial Discharge Measurement on Long Cable Lengths

- **Single-Sided Measurement and PD Origin Localization**



$$X_{PD} = X_{cable} - \Delta t \cdot v/2$$

- Sensitive Dual-Sided PD Measurement



$$X_{PD} = X_{cable}/2 - \Delta t \cdot v/2$$

Why we use damped ac?

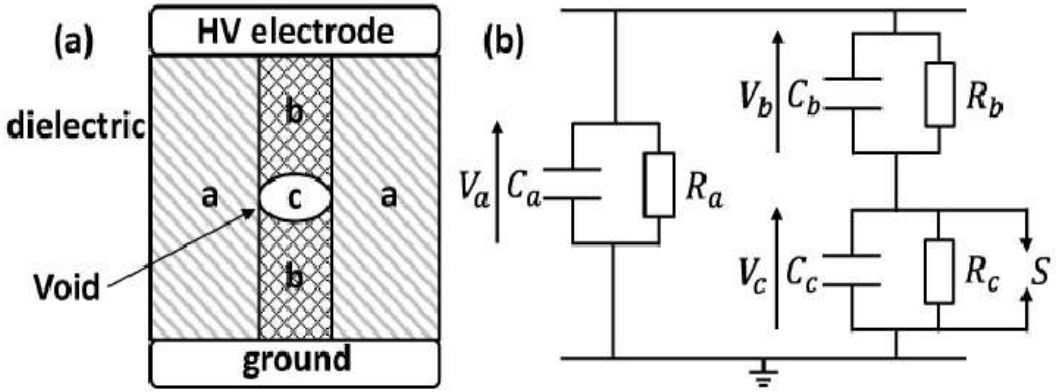
- Lightweight modular system,
- Compactness in relation to the output voltage,
- Low effort for system assembling,
- Low power demand incl. long cable lengths,
- Low level of EM noises and possibility of sensitive PD detection and localization as well as dissipation factor measurements.

Literature Review summary

S.N.	Paper	contribution
1.	P Cichecki," Testing and Diagnosis of High Voltage and Extra High Voltage Power Cables with Damped AC Voltages", DOI: https://doi.org/10.4233/uuid:f50c2129-6771-468b-aa3c-7c1fdac4e425	Discusses the types of defects in cable and to localize and detect partial discharge using damped AC signal.
2.	W. He, Q. Wang, C. Huang, H. Li and D. Liang, "A Cost-Effective Technique for PD Testing of MV Cables Under Combined AC and Damped AC Voltage," in *IEEE Transactions on Power Delivery*, vol. 33, no. 4, pp. 2039-2040, Aug. 2018, doi: 10.1109/TPWRD.2016.2603446	Discusses a cost-effective technique for partial-discharge testing of medium-voltage (MV) cables using a combined ac and damped ac (DAC) voltage.
3.	M. Wild, S. Tenbohlen, E. Gulski and R. Jongen, "Basic aspects of partial discharge on-site testing of long length transmission power cables," in *IEEE Transactions on Dielectrics and Electrical Insulation*, vol. 24, no. 2, pp. 1077-1087, April 2017, doi: 10.1109/TDEI.2017.006311.	The paper discusses basic aspects of selecting an on-site test voltage and the partial discharge measurement under on-site testing conditions of power cable lines with long length.

Work in progress

1. Using HIGH VOLTAGE AC SIGNAL



Modelling of the below circuit in PSPICE and see the effect of void

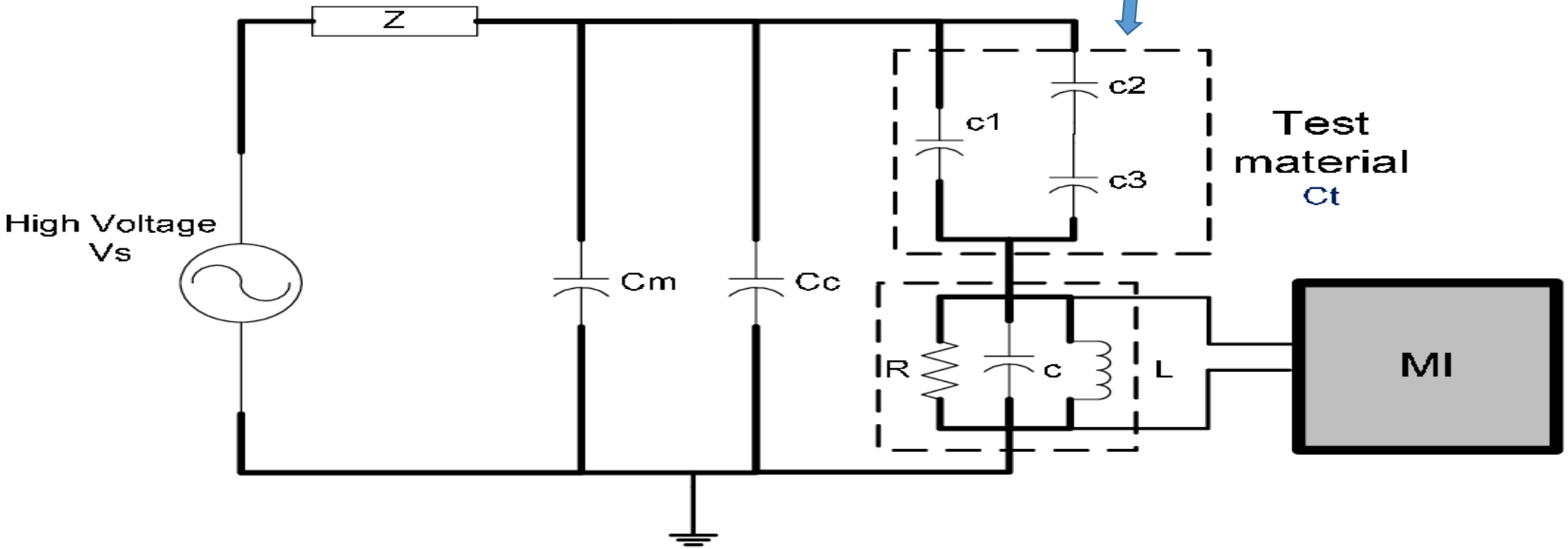
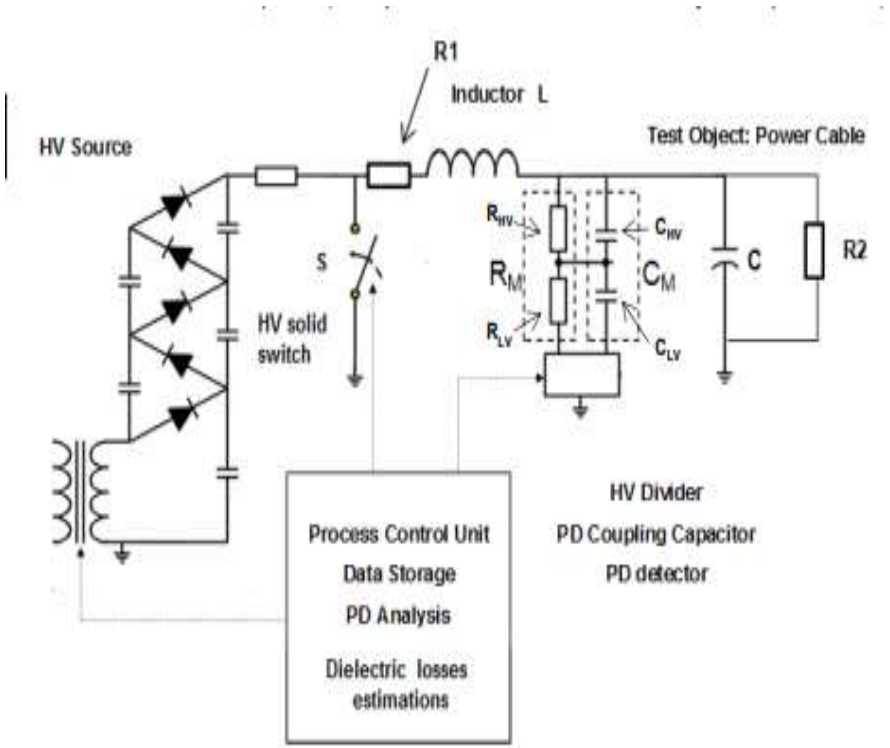
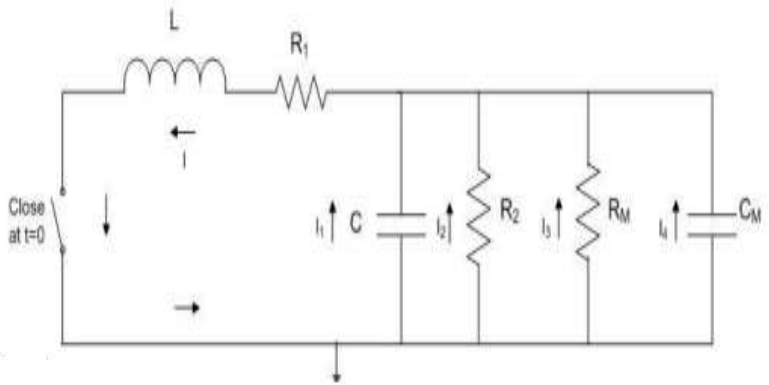


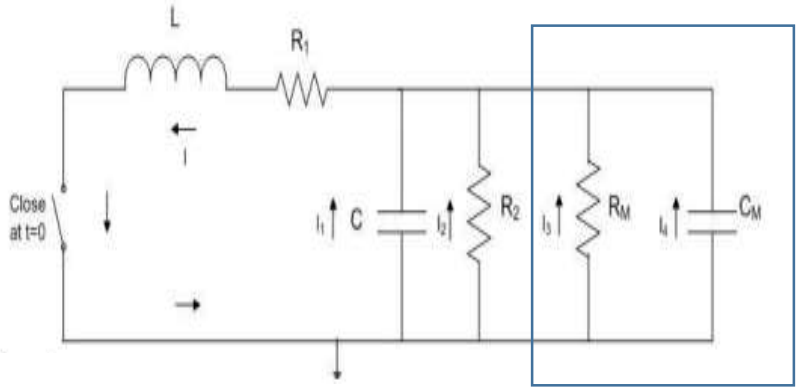
Figure 1. Electrical equivalent circuit model.

2) Using Damped AC signal :

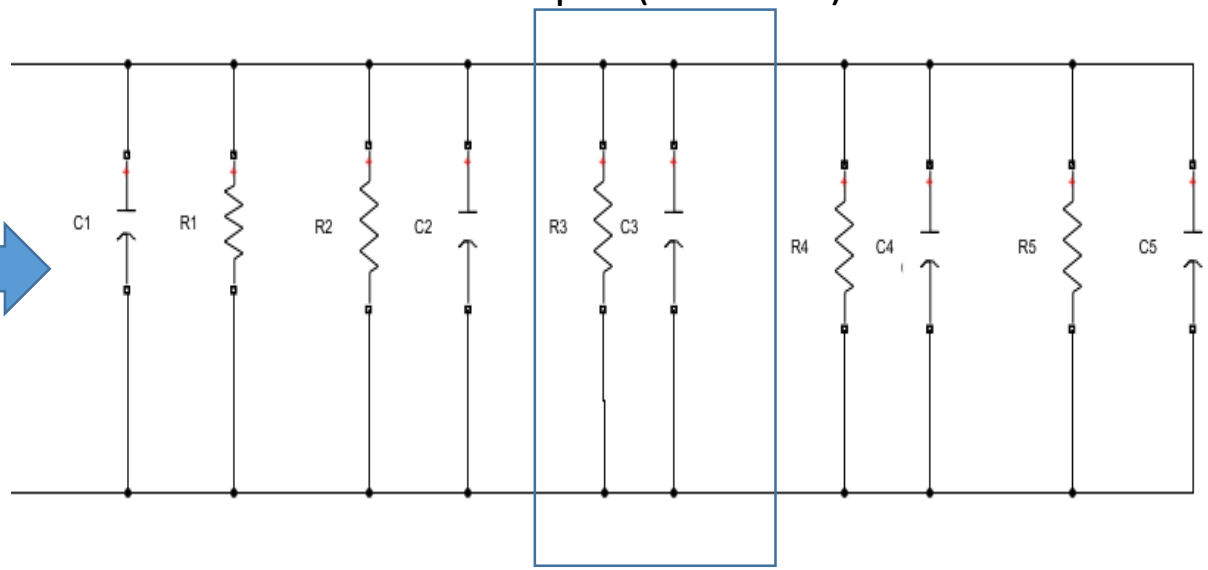
Modelling of the below circuit in PSPICE and see the effect of void

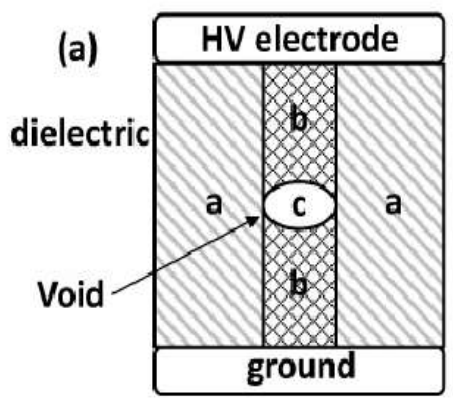


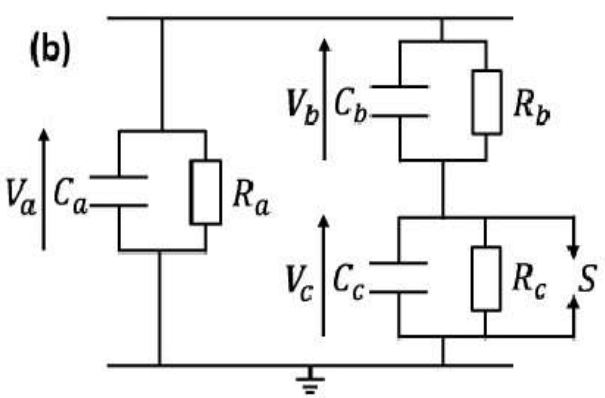




Defective
part(with void)







Research Gap

- There can be multiple defects or voids in the cable. Detecting PD signal from these signal simultaneously will become a cumbersome task.

  PD signal are affected by background noises and electromagnetic interferences, so detection and localization becomes a challenge.

Project Timeline

OCTOBER

Simulation for PD DETECTION on PSPICE
For AC and DAC signal

NOVEMBER

Simulation for PD DETECTION on PSPICE
For AC and DAC signal

DECEMBER

Setting up hardware setup
DAC measurement.

References:

- P Cichecki," Testing and Diagnosis of High Voltage and Extra High Voltage Power Cables with Damped AC Voltages", DOI: https://doi.org/10.4233/uuid:f50c2129-6771-468b-aa3c-7c1fdac4e425

- W. He, Q. Wang, C. Huang, H. Li and D. Liang, "A Cost-Effective Technique for PD Testing of MV Cables Under Combined AC and Damped AC Voltage," in *IEEE Transactions on Power Delivery*, vol. 33, no. 4, pp. 2039-2040, Aug. 2018, doi: 10.1109/TPWRD.2016.2603446

- M. Wild, S. Tenbohlen, E. Gulski and R. Jongen, "Basic aspects of partial discharge on-site testing of long length transmission power cables," in *IEEE Transactions on Dielectrics and Electrical Insulation*, vol. 24, no. 2, pp. 1077-1087, April 2017, doi: 10.1109/TDEI.2017.006311

- Partial Discharges (PD): Detection, Identification and Localization (IEEE Press) by Norasage Pattanadech (Author), Rainer Haller (Author), Stefan Kornhuber (Author), Michael Muhr

THANK YOU