

# **Sensor-based non-intrusive condition monitoring technologies for GIS/GCB**

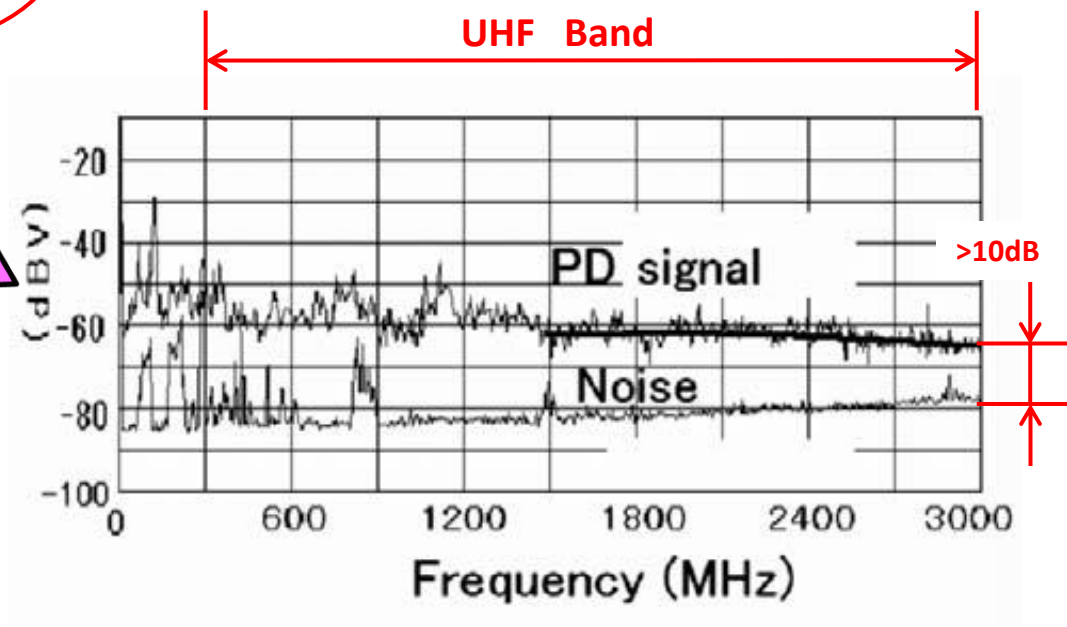
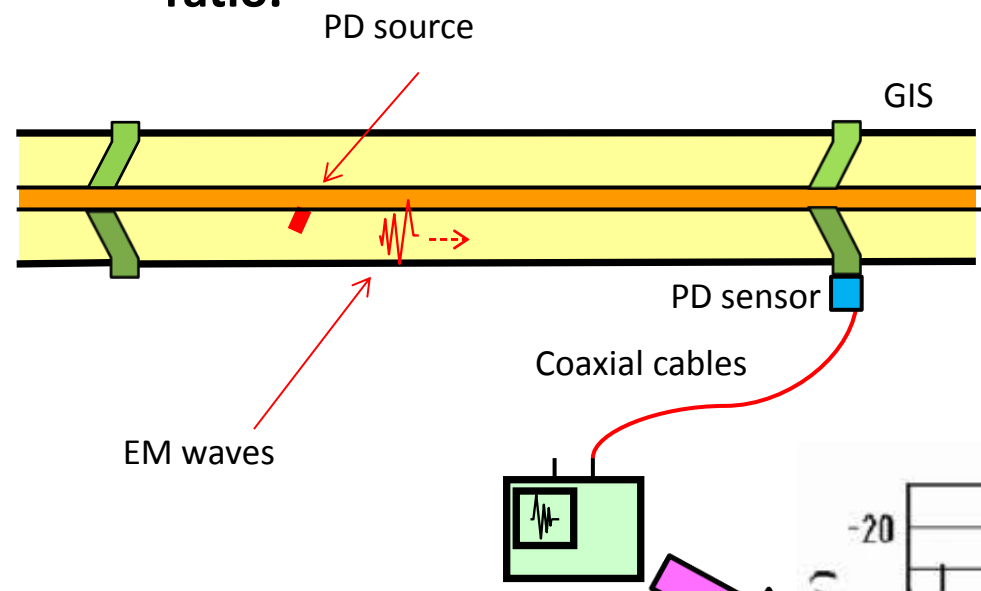
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Japan**



- 1. Introduction**
- 2. Partial Discharge (PD) Monitoring in GIS**
- 3. Identification of PD location in GIS**
- 4. Application to detection of discharge in dead tank  
GCB**
- 5. Conclusions**

- Electromagnetic wave detection with UHF band can achieve a high S/N ratio.

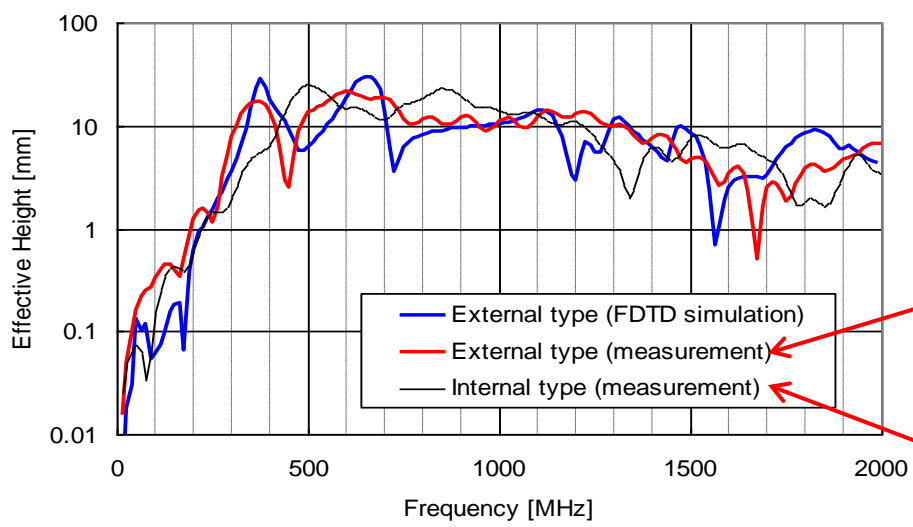
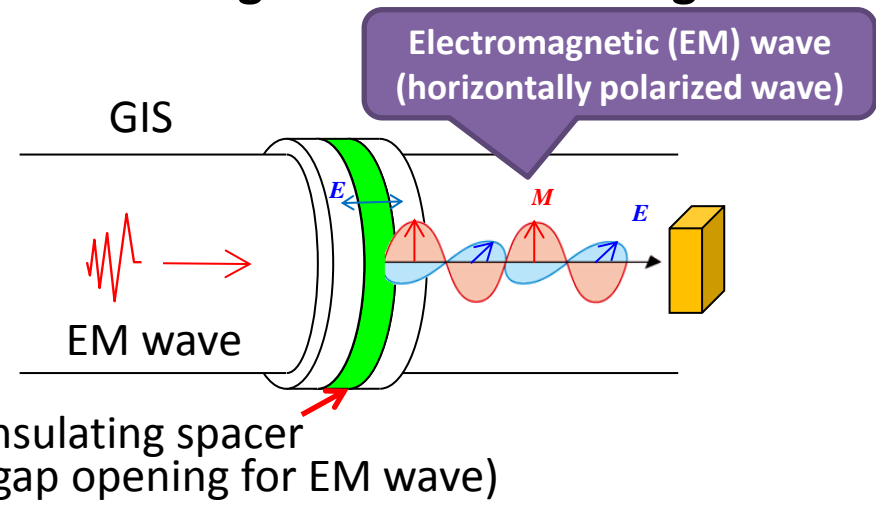


Spectra of PD signal and Noise

# PD monitoring in GIS - PD detection

- Sensitivity of external PD coupler can be also comparable with internal PD coupler when polarized EM waves radiating from the insulating spacer is considered.

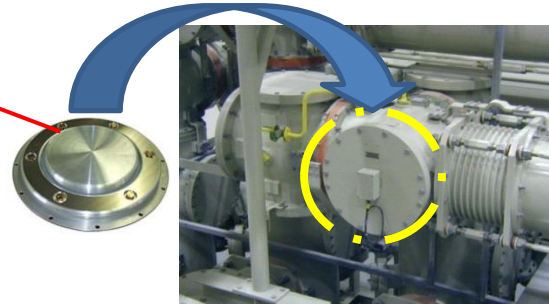
$$\text{Sensitivity} = \text{output [V]} / \text{UHF field [ V/mm]} \\ = \text{Effective height [mm]}$$



Insulating spacer (gap opening for EM wave)



External PD coupler



Internal PD coupler

Analytical and experimental results of sensitivity characteristics

# PD monitoring in GIS - PD detection

Base unit and PC



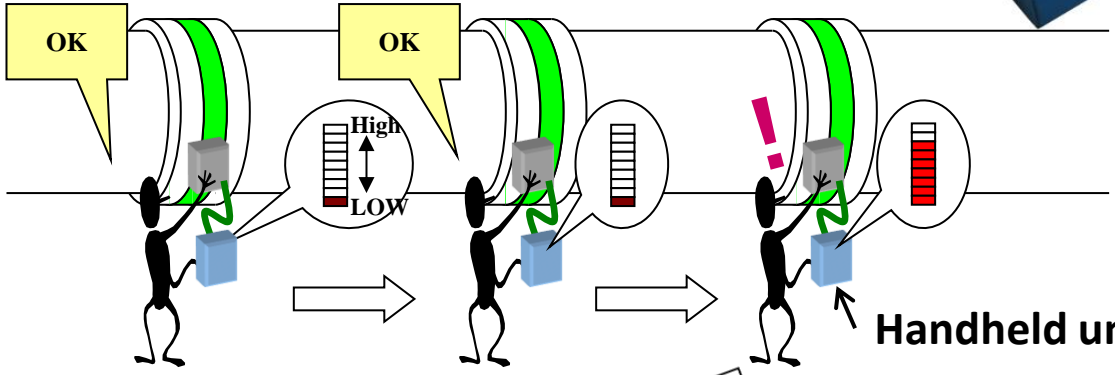
Handheld units



External PD coupler  
(EM wave)

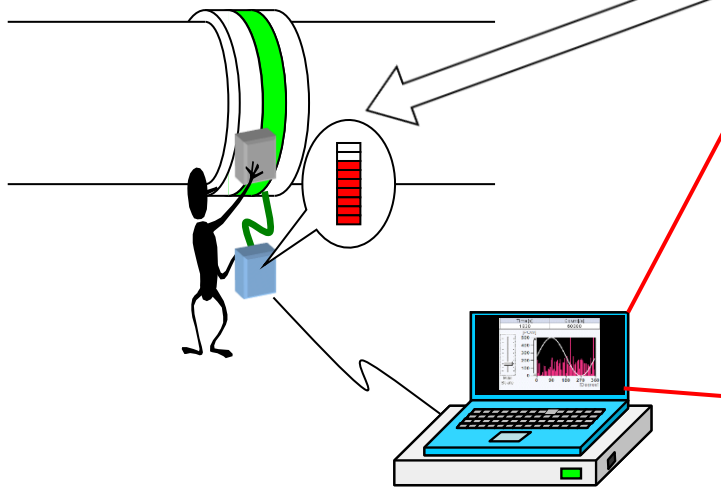
AE sensor  
(acoustic emission)

Primary diagnosis



n: PD pulse count  
q: PD magnitude  
 $\phi$ : phase dependence  
t: continuity

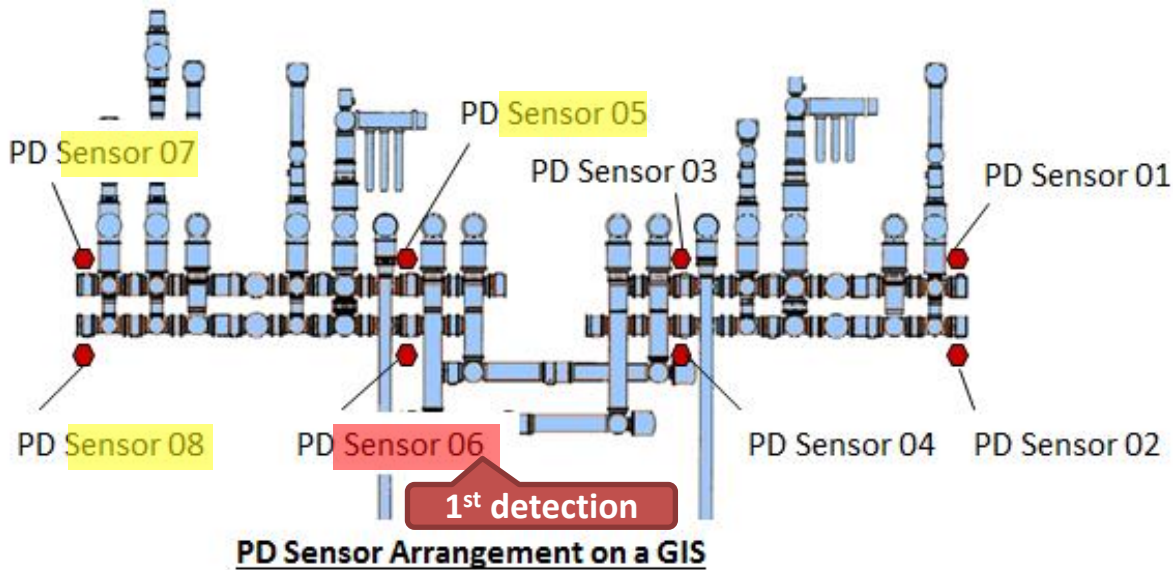
Secondary diagnosis



Real-time display

Continuity check

# Identification of PD location in GIS

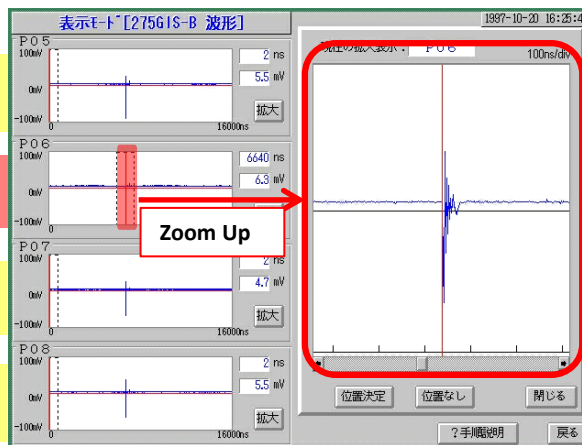


Signal Processing Panel (Outdoor type)

Signal Processing Panel

1<sup>st</sup> detection

- Sensor 05
- Sensor 06
- Sensor 07
- Sensor 08

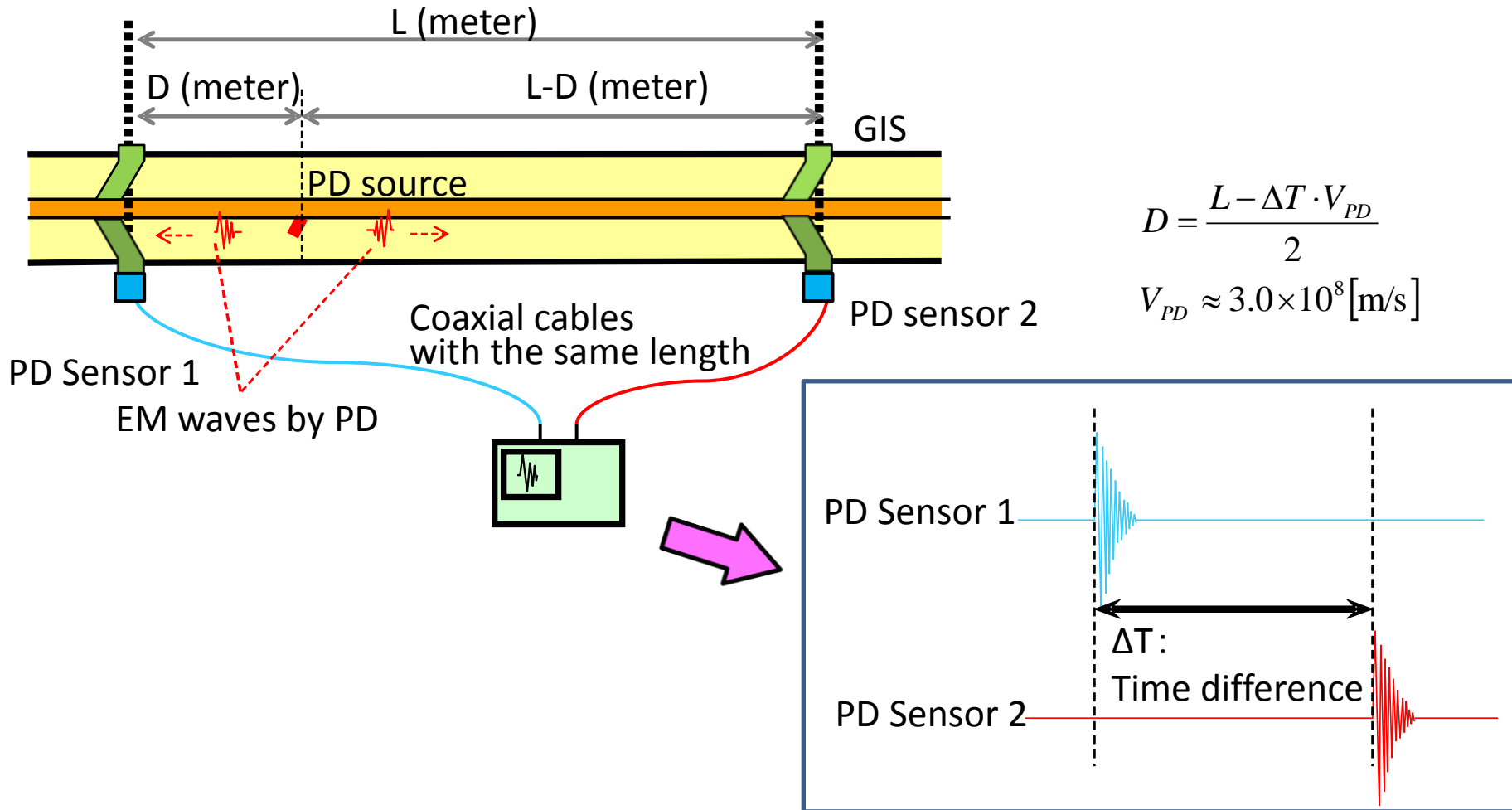


Next page

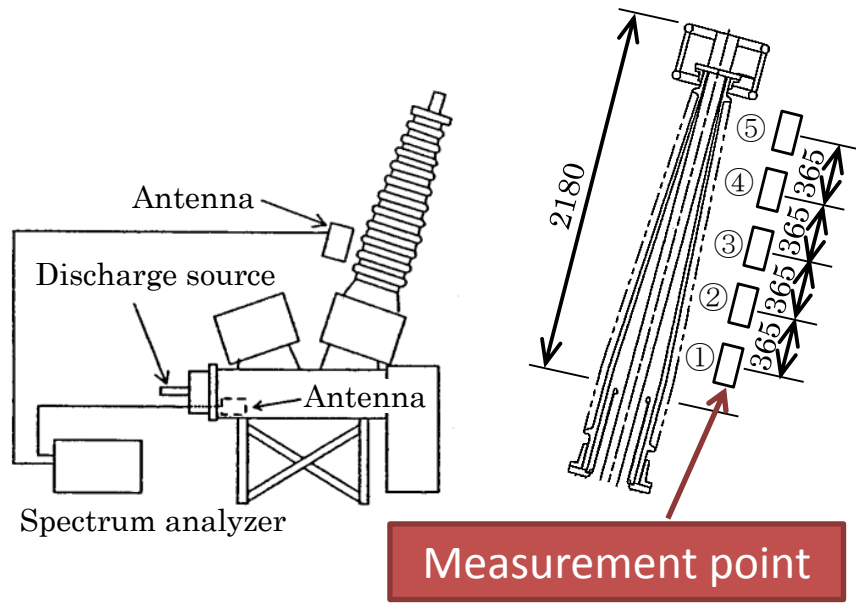


Location of PD: 10.42m from P06 towards P08

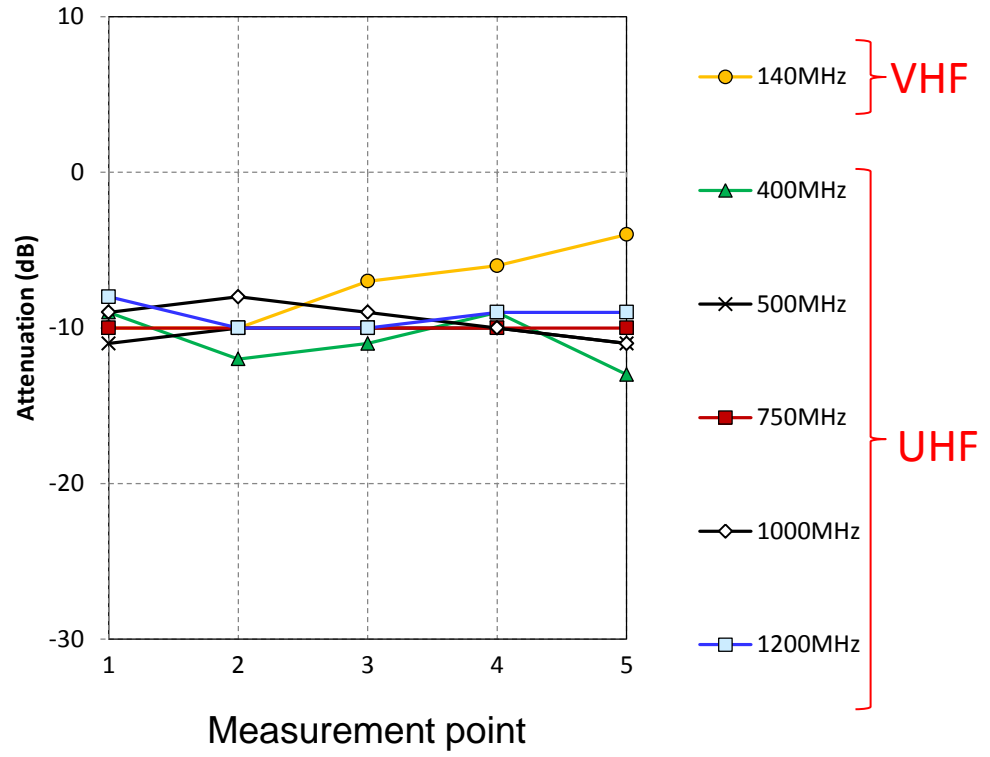
- Identification of PD location in GIS is provided by time of flight method of electromagnetic waves detected by two antennas.



- VHF to UHF electromagnetic wave is emitted from internal discharge through busing.



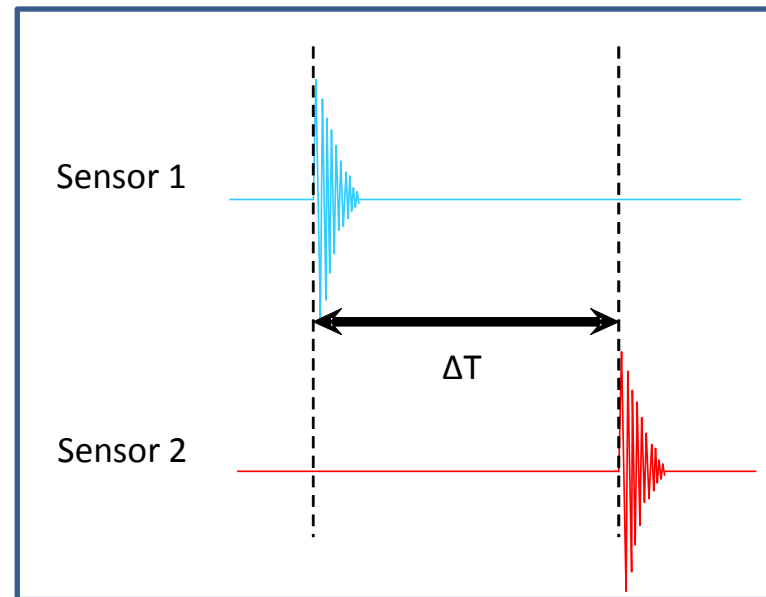
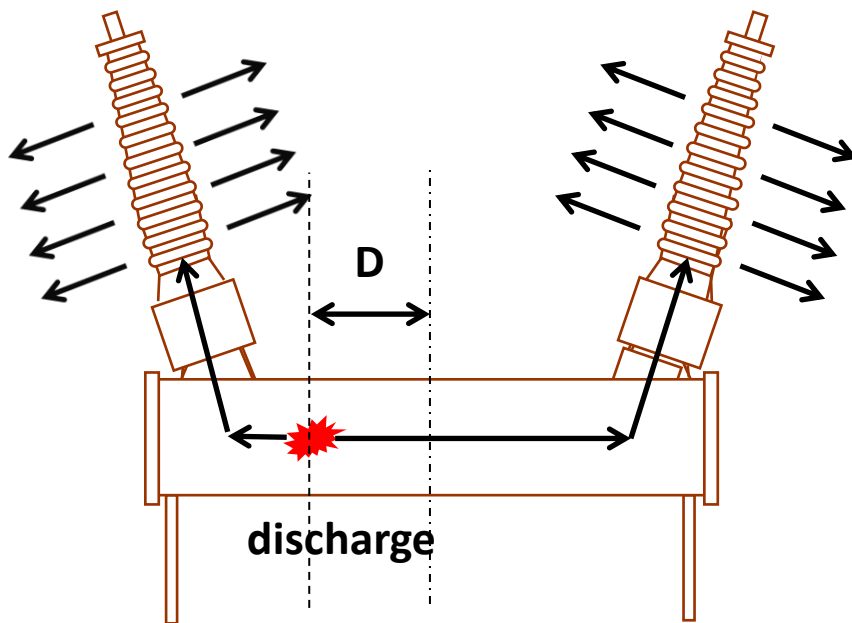
Experimental set-up and measurement point



Attenuation at each measurement point



- Two sensors installed on GCB tank axis can locate discharge point in dead tank GCB.

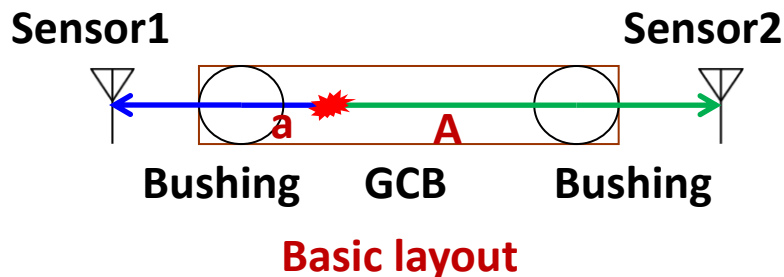


$$D = \frac{\Delta T \cdot V_D}{2}$$

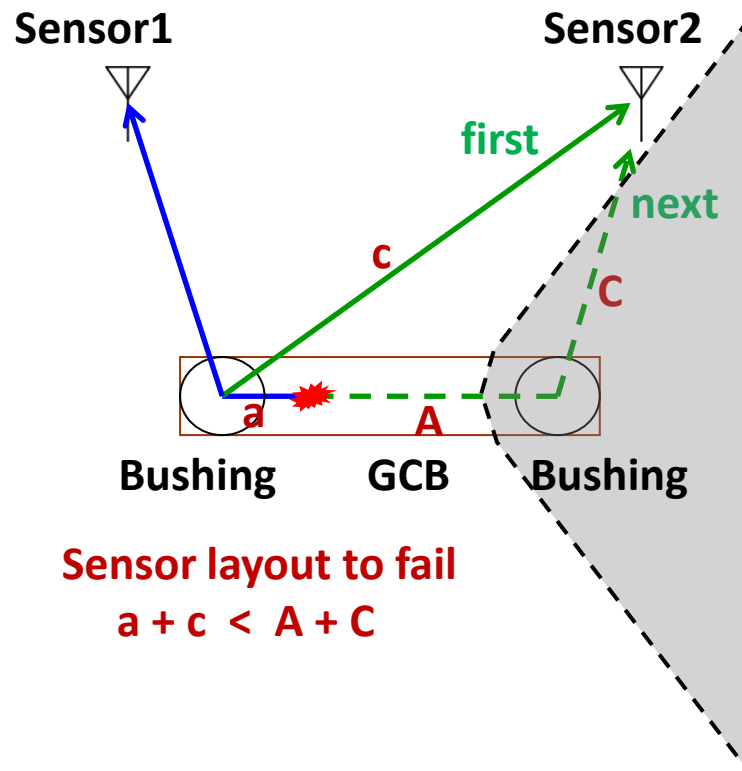
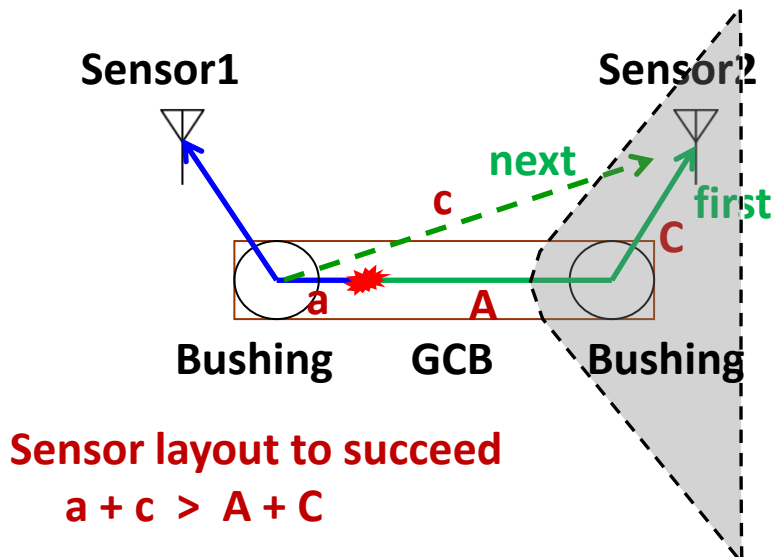
$$V_D \approx 3.0 \times 10^8 \text{ [m/s]}$$

Basic layout of location for dead tank GCB

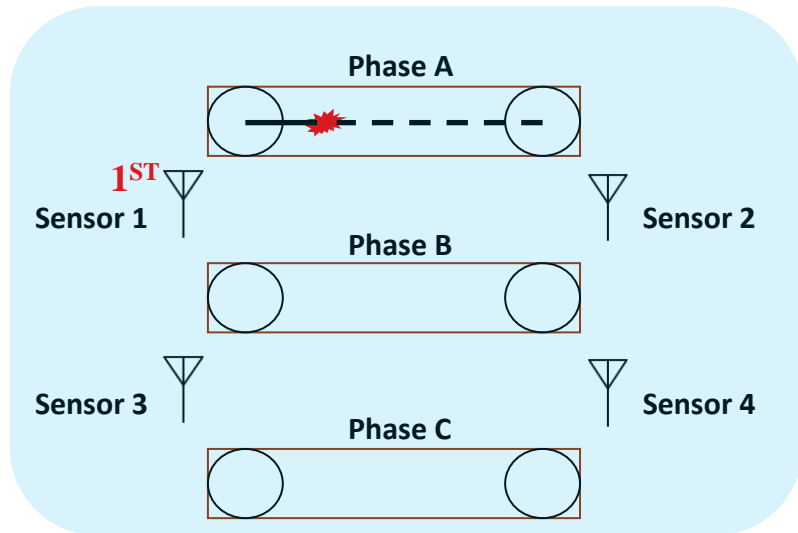
- Sensors should be located at limited area where EM wave radiated from nearest bushings can be detected earlier than that from other bushings.



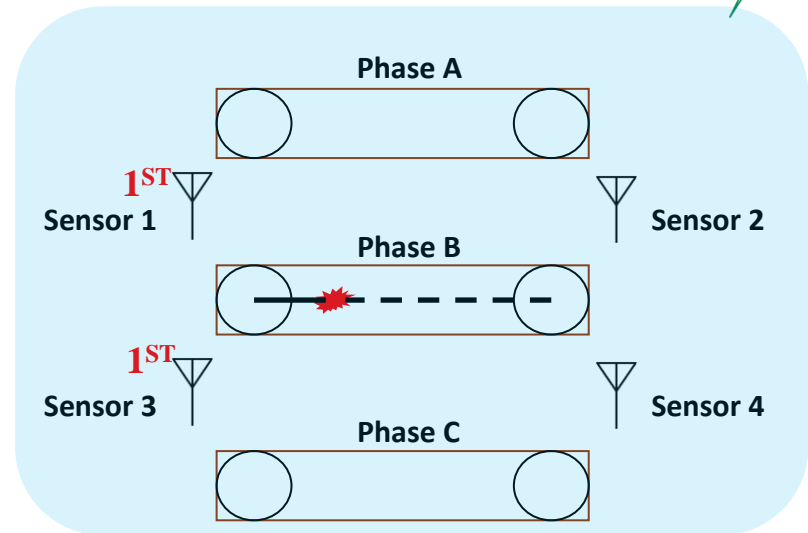
: Discharge point



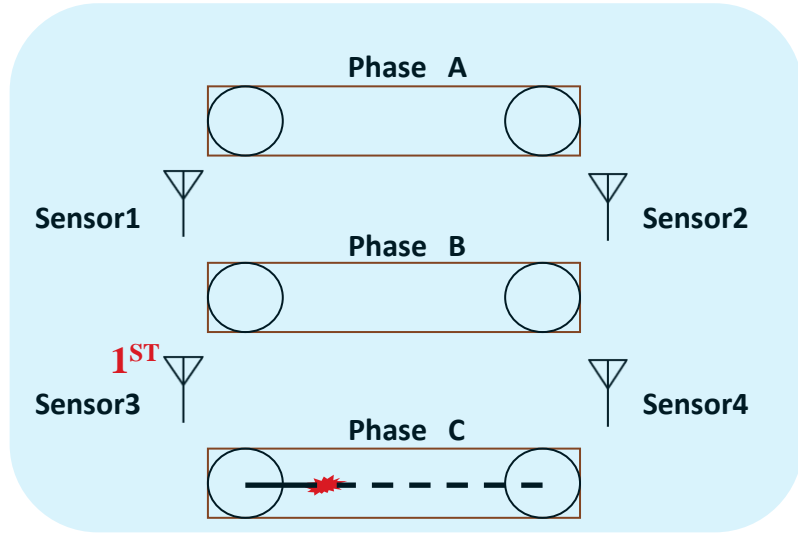
# Location of sensors to detect and locate discharge in three phase dead tank GCB



**Discharge in phase A**



**Discharge in phase B**



**Discharge in phase C**

: Discharge point

1 <sup>ST</sup> detection	Discharge location	Sensors used for detail location
Sensor 1	Phase A	Sensor 1-2
Sensor 2		
Sensor 1 & 3	Phase B	Sensor 1-2 or Sensor 3-4
Sensor 2 & 4		
Sensor 3	Phase C	Sensor 3-4
Sensor 4		

- ❑ External and internal PD couplers to detect PD in GIS are introduced. Sensitivity of external PD coupler is comparable with internal PD couplers when polarized electro magnetic wave is detected through insulating spacers.
  
- ❑ Partial discharge location system is introduced. It can identify the distance between the partial discharge and PD sensors using partial discharge signals.
  
- ❑ Identification of discharge location in dead tank GCB is presented. Four discharge sensors based on PD couplers and identification principle for PD location enables the phase detection and location where discharge occurs. Layout of the sensors is an important factor for precise identification of discharge location.