Portable Acoustic Flashover Location Detector for Gas Insulated Switchgears at a Fraction of Cost

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Abstract: ***This document gives a brief description about how low cost Sound detectors can be used for detecting the location of flashover in High Voltage testing of Gas Insulated Switchgear (GIS) at factory or at site during commissioning and "Are high accuracy sensors really needed?" The detection of flashover location inside a metal enclosed GIS insulated by dielectric gas (e.g. SF6) has always been a very difficult and tedious task. At present, this issue is tackled by means of thermal/acoustic cameras and arc sensors. The method proposed in this document incorporates acoustic sensors at various locations which help in determining exact location of fault in GIS. This document suggests that the primary need is to know the location of fault and thus there is no requirement for any analysis after the fault has happened during testing. Because mostly the faults during testing of gas insulated switchgear happen due to presence of particle inside the compartments which can be rectified by cleaning. Thus, this paper postulates the most compact method to locate fault in different compartments in GIS. Further, the need of a separate analyzing kit is eliminated and thus making it more compact and mobile. Experiments were conducted in this direction, with acoustic sensors applied to the 245 kV GIS product. The observations bolstered the principle incorporated and the exact modules which encountered flashovers were identified accurately.***

Keywords: Gas insulated Switchgear, flashover detection, high voltage testing, acoustic sensor

1. Introduction

The GIS faults are of a typical type. Flashover is caused by presence of particles in an enclosure, protrusion on surface, presence of moisture etc. Majority of faults are caused due to presence of some foreign particle in SF6 gas. The source of any flashover can be easily identified by visual inspection by opening up the compartments. It is of paramount importance that the fault is rectified before the GIS is put in service. For locating the flashover in various compartments of GIS commonly known methods are thermal camera, acoustic cameras, piezoelectric sensors, arc sensors etc. These methods mentioned above exhibit some drawbacks I.e. inability of arc sensors to pin-point the fault, unnecessary cost involvement in acoustic camera, bulkiness etc. These deficiencies not only restrict their usage but also cost extra money, space and complexity.

There has been a lot of research on using acoustic sensors for measuring partial discharge (PD) in various high voltage equipments [1]. The method presented in this paper derives advantage from the concept that after the flashover has taken place, the most concerned part is its location and further rectification. Analyzing part can be done once the GIS is opened. Thus, basic need is to find the module in which the fault is occurring. Keeping the said pragmatic perspective in mind, method uses less sensitive low cost sound sensors.

Secondly, the integrated display ensures that separate analyzing kit is eliminated. The sensors are battery operated which can be recharged. This feature would be very effective in difficult site conditions, where getting auxiliary supply is very difficult. Thus, extra cost, space and complexity have been further eliminated by the proposed method. Prototype testing was carried out. The sensors were tested on actual product and tests and experiments were carried out in a high voltage lab. The results were very much accurate.

2. Operation Principle & Experimental Setup

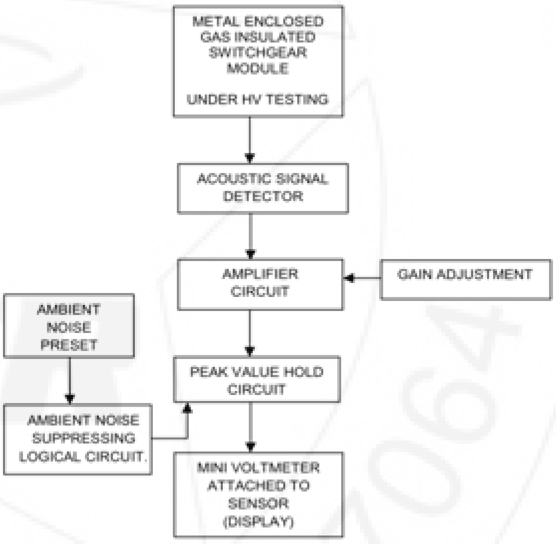

Figure 1: Block Diagram of the circuit

- Novelty of the circuit lies in its application in GIS. Every flashover causes a sound in the audible frequency range which can be recorded using a sound sensor (e.g. condenser microphone).The recorded sound is then converted to voltage with adjustable gain.
- As the flashover will last only for a few milliseconds, a peak hold circuit is also embedded in order to hold the peak of the recorded value.
- Further a noise suppression circuit is used to suppress the external noise, reference of which can be preset either manually or automatically.
- The recorded sound is now compared with the preset noise. This is displayed using a mini voltmeter screen on the sensor itself.
- In flashover detection unlike partial discharge we are only concerned about the amplitude of the sound wave and not

the frequency. In other words we would require only the peak of each detector.

The circuit is also entails following advantages:

- Gain adjustment tab provides ease of operation by making the received signal prominent as compared to ambient noise
- It allows ambient noise to be adjustable as it differs from site to site.

Experimental setup

The basic test setup consisted of three GIS modules with SF6 gas pressure in respective module at 6.1 bar rel. at 20^{o} C. Artificial flashovers were created in GC1 (Gas compartment 1) by reducing the SF6 gas pressure. Decreasing the gas pressure resulted in a decreased dielectric strength which triggered the flashover. Test sequence was carried out with two sensors fixed at specific locations from 1 to 4 as explained in table 1 and observations were noted down.

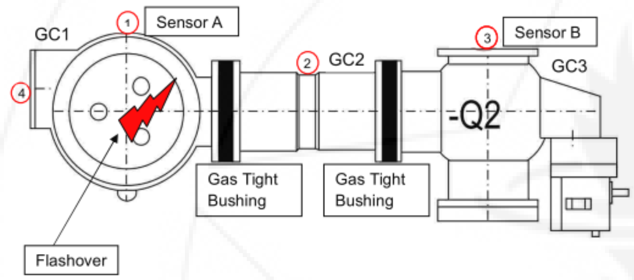

Figure 2: Experimental setup

After completion of this experiment, we applied the concept on 245 kV GIS (see figure 3).

The sensors were mounted on each module to get the specific location at which flashover occurred. Sensors were provided with straps and thus attached on the outer surface of housing. Artificial Flashovers were created in compartments Q9, Z1 & T1 one after the other and results of all the sensors were noted down.

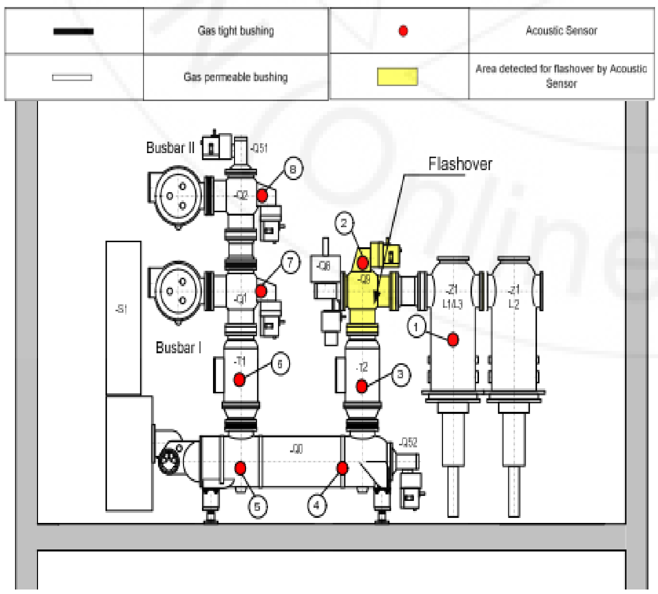

Figure 3: Flashover in Q9 with acoustic sensors

3. Observations

Below unknown factors make expression for damping a lot more complex:

- The amplitude of the acoustic signal will decay inversely proportional to the square root of the distance from the source, as the sensor is moving away from the source [2].
- The damping also depends upon the material composition of enclosure which is the major carrier of sound.
- The shapes of various modules affect the sound trajectory.

The observations found are listed in following tables.

Table 1: Test Results (refer fig.2)

Test seq.	*Sensor A location*	*Sensor B location*	*Sensor A Reading (V)*	*Sensor B Reading (V)*
1	1	3	2.686	1.798
2	1	2	2.683	2.091
3	1	4	2.687	2.622

In all the test sequences, the high value shown by Sensor A clearly depicts that flashover location lies in Gas compartment 1 (GC1).

Test on 245 kV GIS:

Table 2: Test Results (refer fig.3)

Sensor No.	Readings (V)		
	TEST 1	TEST 2	TEST 3
	Flashover Location Q9	Flashover Location Z1	Flashover Location T1
1	2.32	2.71	0
2	2.72	2.25	0.08
3	2.4	1.77	0.49
4	1.54	0.82	1.55
5	1.34	0.27	1.81
6	0.37	0	2.71
7	0.09	0	2.53
8	0	0	1.76

Here, the values can be plotted as shown.

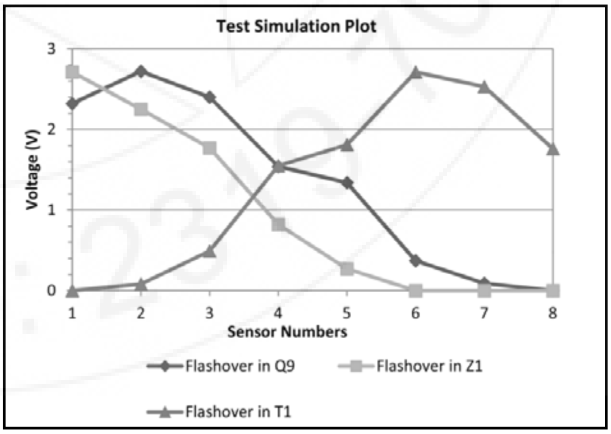

Figure 4: Test Simulation Plot

The graphs clearly show peak value at the compartment which has shown fault occurrence. Thus, the proposed acoustic sensors were effective in determining exact fault location. If we were using arc sensors for TEST 1 in table 2 [3], the area of detection would be as shown in figure 4 because it works on light capturing phenomenon. Same area would be detected in TEST 2 also. The same zone detected for TEST 1 & TEST 2 as they comprise single gas compartment would make the rectification process by opening up the modules a lot cumbersome and tedious as the exact location of the flashover is not known. While with acoustic sensors, decaying sound clearly suggests which module is faulty.

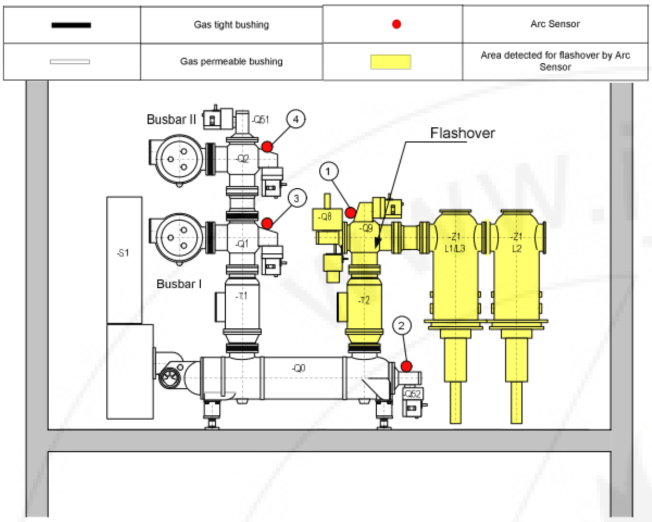

Figure 5: Flashover in Q9 with arc sensors

4. Conclusion

Flashover location detector for gas insulated switchgear using low cost acoustic sensors is proposed in this paper. Experimental results prove the proper functioning of sensors in determining exact location and module of flashover. The modules which faced flashovers were correctly identified. This measuring technique not only helps in saving man-hours but also is less complex than the conventional methods. It is viable to use at factory as well as site & can be used for all types of GIS.

5. Future scope

This invention can be modified to get connected to SCADA with continuous power supply to the sensors for continuous monitoring of GIS on site. Secondly, with some slight modifications the sensors can also be applied to dead tank electrical equipments. Its range of application can be extended to any device which consists of multiple compartments and is susceptible to electrical faults & flashovers. Lastly, authors are working on making it wireless. This will ensure the communication among sensors and triggering an alarm from the sensor

References

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