MONITORING OF LEAKAGE CURRENT AND WEATHER CONDITIONS TO EVALUATE PERFORMANCE OF INSULATING SYSTEMS IN THE FIELD

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Abstract: Leakage current in the surface of insulating systems, such as insulators, fuse cut-outs, switches, surge arresters and bushings, represent a problem for the utility. It leads to losses, audible and electromagnetic noise, damage to polymeric housing and, ultimately, it can cause the insulation system to fail, which degrades the supply quality indexes of the utility. The measurement of the leakage current is an important tool to study the insulation system performance, as reported in the literature, but it is also known that the leakage current is also dependent on weather and contamination conditions. In this work, a portable leakage current monitor has been developed and, besides the leakage current, it also records humidity and temperature, as means to allow a more significant analysis of the insulating system performance. Field results are presented which show the application of the developed tool.

1 INTRODUCTION

The performance of insulating systems used in distribution feeders, such as insulators, switches, fuse cut-outs and surge arresters is a concern for electricity utilities because that their failure can put the feeder out of operation, degrading the quality indexes of the utility [1-3]. The performance of the insulating system is a function not only of its profile, construction materials and manufacture control, but also related to the place where it is installed [3-5]. The ambient, weather and contamination conditions can deteriorate the performance of such insulating systems in many ways [6, 7]. Salt from sea, metal dust from mining operations, cement industries, snow, fog and rain are some examples of such conditions that have been studied in the literature [7, 8].

The leakage current which flows on the surface of insulating systems is an interesting variable that is used to study their performance . Many features of the leakage current have been analyzed: magnitude, RMS, peak, frequency and wavelet analysis and pulse counting are some examples [9-12].

In this work, a portable leakage current monitor was developed and installed in different places, with different ambient, weather and contamination conditions. The developed device, which measure and records the peak value over a set time period, also measure and records some ambient variables, humidity and temperature. In the following, a description of the developed device is made, results from field application are shown and conclusions are made. The conclusion shows that the study of insulating system performance of insulating systems based surface leakage current is better understood when ambient conditions are also taken into account.

2 LEAKAGE CURRENT MONITOR

In order to investigate the performance of insulating systems, a leakage current monitor was developed. It is based on a programmable microprocessor, portable, and can run either on batteries or the low voltage side (220V) of the distribution network. There are two modules, a measurement module (local unit) and a recorder module (central unit), which are connected though optic fibers. Figure 1 shows the general arrangement of the device.

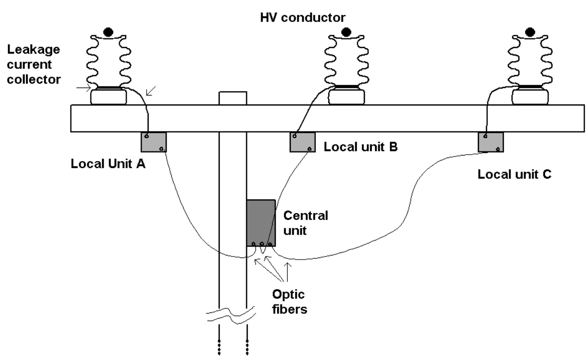

Fig. 1: General arrangement of the local and central units of the leakage monitor for three pillar insulators.

In the following sections, more details about the developed device is presented.

2.1 Local Unit

The local unit, which is responsible for the leakage current measurement is described in Figure 2. On the bottom ceramic part of the insulator, a metal ring is tightened and an electrical conductor is attached. The leakage current collected by the metal ring is fed to a shunt resistance in the local unit by the electrical conductor and is returned to the metal end of the insulator. The acquired signal is then processed by a 16F microprocessor family in terms of its peak value, taken over a 30 seconds period. Every 30 seconds, the peak value is then sent to the central unit through optic fibers, preserving the insulation from HV to LV sides. The local unit employs a 12V battery of 7200 mAh.

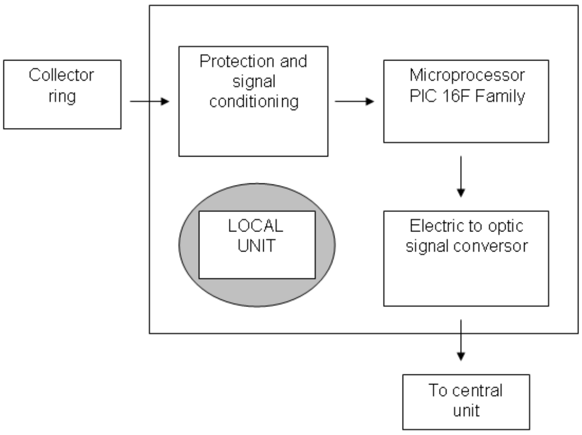

Fig. 2: Block diagram of the local unit, responsible to collect the leakage current, perform data acquisition and send the information by optical fibers to central unit.

There are three local units per central unit, so all three phases on each insulator can be measured.

2.2 Central Unit

The central unit receives the optic signals from the local units and transform them back to electrical signals. The electrical signals are then acquired and processed by a microprocessor, which also acquires humidity and temperature. These information is sent to another microprocessor, dedicated to record the information in a memory card. The block diagram of the central unit is shown in Figure 3.

The central unit has an 4x16 characters LCD display that helps to verify operation after installation. The LCD can be turned off to save the batteries. The local unit can run on one battery for more than one month, while the central unit runs for about one week. To record data for longer periods, more batteries are required. The configuration used in this study used two batteries in the central unit, allowing data recording

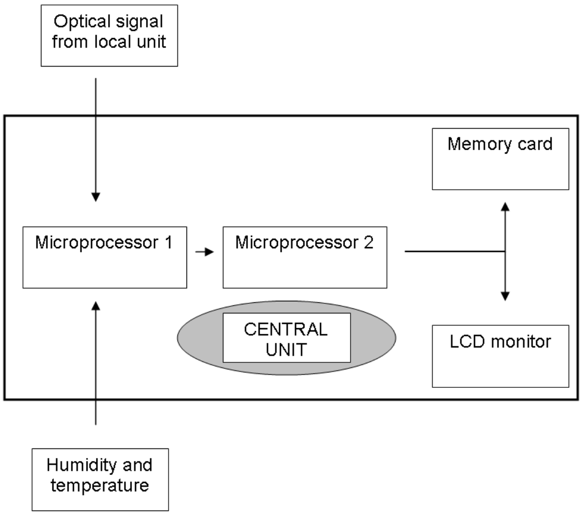

Fig. 3: Block diagram of the central unit, responsible to receive optical signals from local units and record the peak values in a memory card.

3 FIELD APPLICATION

After calibration procedures, the developed leakage current monitor was installed in the field. Figure 4 shows one of the installations accomplished.

Fig. 4: Photograph showing the field installation of the three local units, close to each pillar type insulator, and central unit, attached to the pole, connected through optical fibers.

The field installation is simple and takes less than one hour to be done. The electricians must attach two metal rings per insulators, fix the local and central units, and connect the optical fibers.

4 RESULTS

Figure 5 to 7 show the data recorded during almost four days. The measurement started at about 9 a.m. and the place is of urban type, but close to some vegetation. Figure 5 shows the leakage current over the surface of three insulators, under the voltage of 25 kV phase-to-phase.

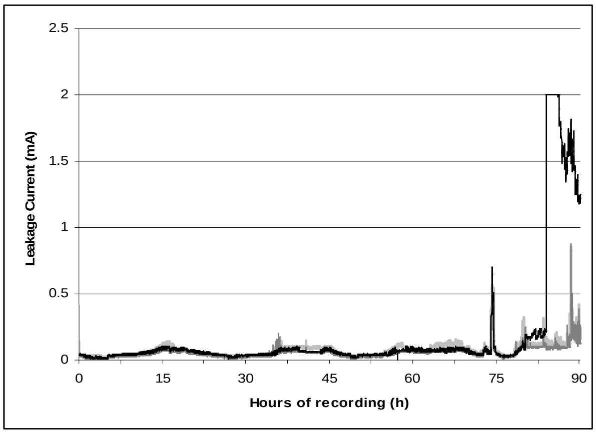

Fig. 5: Peak of leakage current on three 25kV pillar insulators, under voltage of 25 kV, phase-to-phase, recorded in a urban area.

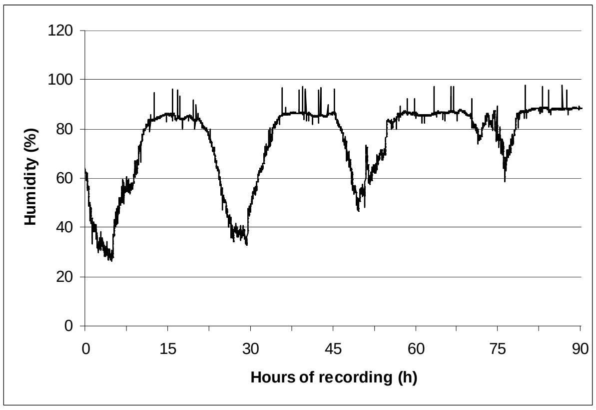

Fig. 6: Ambient humidity, recorded at the same time as shown in Figure 5.

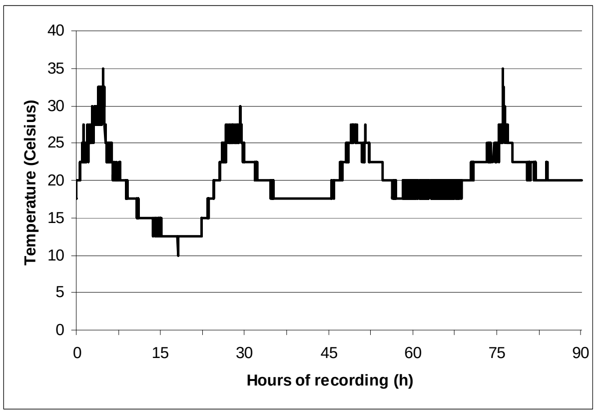

Fig. 7: Ambient temperature, recorded at the same time as shown in Figures 5 and 6.

Figures 8 to 10 show the data recorded for the same type of insulators shown in figures 5 to 7. It was applied the same voltage, but the installation was in a rural area, close to a sand road and very dusty.

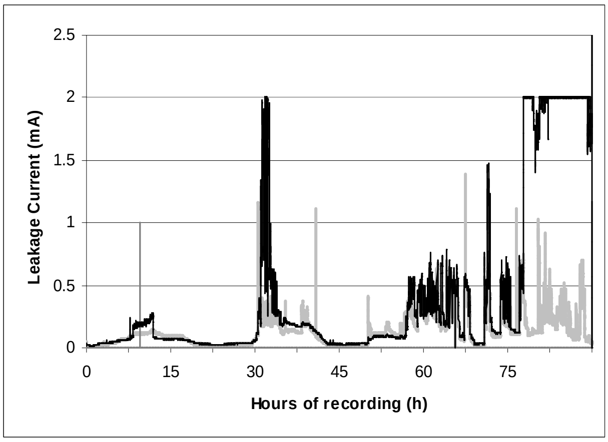

Fig. 8: Peak of leakage current on three 25kV pillar insulators, under voltage of 25 kV, phase-to-phase, recorded in a rural area.

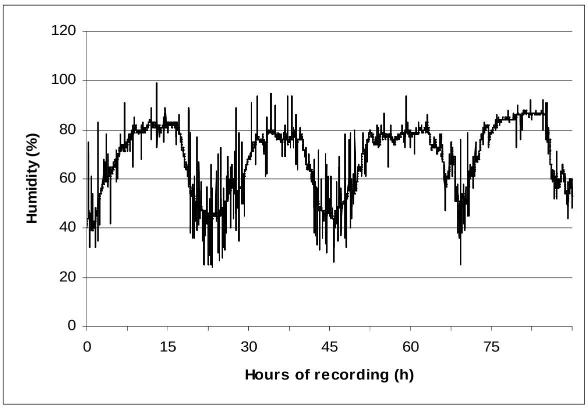

Fig. 9: : Ambient humidity, recorded at the same time as shown in Figure 8.

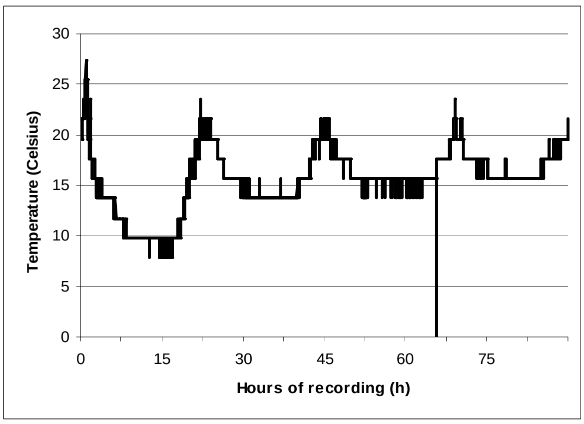

Fig. 10: Ambient temperature, recorded at the same time as shown in Figures 8 and 9.

5 ANALYSIS

The leakage current shown in Figure 5 presents some oscillation due to the variations of the ambient humidity and temperature. During day time, under dry conditions, the leakage current recorded has an average peak value of 0.03 mA, approximately. Under night time, the average Peak current is around 0.1 mA. It can be observed that, for the urban ambient conditions, the behavior of all three insulators were about the same.

One of the insulators installed in the rural area had shown very little constant current, due to possibly some problem in the installation. Despite of this problem, the other two insulators had similar current magnitude up to 75 hours of installation and, after that, one insulator had shown higher leakage current peaks than the other one.

Comparing the performance of the insulators installed in urban area with those installed in rural area, it can be seen, from figures 5 and 8, that the insulators in the rural area had a more current spikes over the recording hours. The average of the leakage current peaks on the surface of insulators installed are show in the Table I.

Table I: Average of the leakage current peaks of the insulators installed.

Insulator #	Leakage Current (uA)	
	Urban	Rural
1	78	142
2	55	0
3	177	415
Average	103.3	278.5*

* average of insulators 1 and 3 only.

It can be observed that the average of the leakage current peaks, shown in Table I, is higher for insulators installed in the rural area, despite of its lower humidity. Due to contamination on the surface, as seen in Figure 11, the insulator in the rural area can retain more humidity, thus increasing leakage current.

(a) (b)

Figure 11: Photographs of the insulators in urban (a) and in rural (b) areas.

6 CONCLUSION

A leakage current monitor was developed and installed in the field to monitor leakage current in three insulators, simultaneously. It can also measure and record ambient humidity and temperature. The results from such device can help to understand and improve the performance of distribution insulators in the field, and information about humidity and temperature are very important variables related to leakage current.

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