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THE ELECTRICAL-METEOROLOGICAL MONITORING CONDITIONS IN SÃO BERNARDO DO CAMPO, SÃO PAULO STATE: SYSTEM IN DEVELOPMENT

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Abstract - This paper describes an integrated campaign for monitoring the electrical-meteorological conditions in São Bernardo do Campo city (known as ABCD region of São Paulo State) that begun in November, 2004. To realize this work it was developed a network using local technology that consists in Electric Field Mill sensors (EFM), Slow Antenna (Flat Plate Antenna) and video cameras. All sensors are synchronized by a Global Position System (GPS) receiver. The Electric Field Mill sensors measure the local changes of the electric field by storm and transients pulses caused by the flashes. The Flat Plate antenna measures the individual electric field changes in the same flash. A video camera capture images of the lightning flashes which were used to validate the recorded data from the sensors.

1 INTRODUCTION

The atmospheric electric field has been studied for a long time. As instruments have been improved, measurements have been made both near the ground and at altitude in the study of weather in general, as well as of weather phenomena such as lightning storms.

The static electricity present on items and surfaces is measured and detected at a distance through electrostatic field meter instruments. These instruments can be used to estimate risks of upset of microelectronic equipment by static discharges, risks of ignition of flammable gases and vapors by static charges on structures or surfaces etc.

When a direct lightning reaches a building, it causes several malfunction or damage to the electric and electronic equipment installed inside, due to the electromagnetic fields and their induced effects. Thus, the evaluation of the electromagnetic field derived from the lightning can be done through the field mill [1,2] or induction probe instruments [3].

The electric field at an earthed fieldmeter is arranged to induce a charge on an area of a sensing surface that has a defined capacitance to earth. In this case, the signal V (in volts) available for the preamplifier input is [2]:

$$V=(\varepsilon_o.A.E)/C \quad (1)$$

where ε_o is the permittivity of free space, A is the sensing surface area, E being the electric field and C as the input capacitance.

Taking into consideration a depth of modulation f of the observed electric field by the rotation of the chopper, the signal V is given by [2]:

$$V=(f.\varepsilon_o.A.E)/C \quad (2)$$

The electric field mill is a sensor widely used by the researchers but typically it is very expensive. Then, after analyzing some technical parameters, it was concluded that it is possible to develop a similar field mill instrument and a complementary meteorological monitoring system using our own technology, as it will be presented as following.

2 DESCRIPTION OF THE NETWORK SYSTEM DEVELOPED

In order to monitoring the electrical-meteorological conditions it was proposed and developed a system that is composed by two types of discharge atmospheric sensors (flat-plate and field mill developed using our own technology), a GPS (Global Position System receiver), video cameras to observe the lightning, a commercial meteorological system (it analyze pressure, temperature and wind conditions), where all equipment / instruments are connected in a computer network. The schematics of all system is presented in figures 1 and 2.

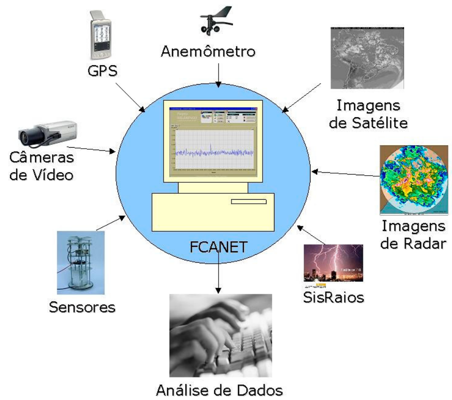

Fig. 1 – Overview of the FCANET LIGHTNING NETWORK developed.

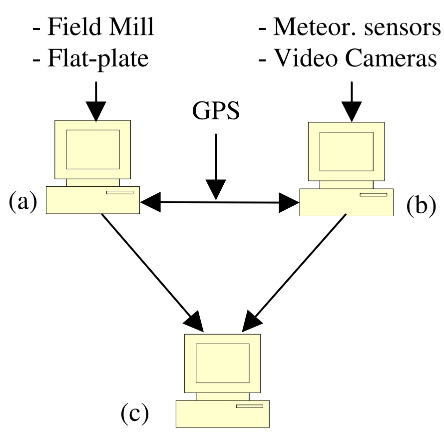

Fig. 2 – Schematics of the computer network details.

As shown in figure 1 it is possible to observe details of the monitoring system developed. Sensors (wind conditions, GPS, field mill and flat-plate) and the video cameras are responsible to measure the local events. In order to improve all local analyses, satellites images are used for the weather's synoptic. The Sisraios system works together with the sensors in order to improve all measurements.

As presented in figure 2, basically the computer (a) is responsible to monitoring the field mill and flat-plate sensors and store all data. The machine (b) stores the information concerning the weather (temperature, pressure and wind) conditions besides the images that come from the video cameras. Every experimental data stored are synchronized with GPS. In order to analyze all atmospherics discharges registered by the system, there is another computer (c) where the captured lightning images are compared with the discharge sensors data and analyzed.

The proposed field mill developed is composed by three plain and parallels metal sheet (blades), where one pair behaves like a capacitor since one plate is grounded and the other one being the sensor, charging or discharging according to the measured field provided from the clouds. This causes an electrical signal proportional to its intensity when exposed to the field. The third one is a rotating electrode, connected to an ordinary AC motor.

The electric field mill developed was made using stainless still and aluminum to minimize the oxidation caused by the weather conditions, as presented in figure 3. The prototype developed has its diameter being 16 cm and height equal to 37 cm. The instrument body is grounded in order to protect the inside electronics.

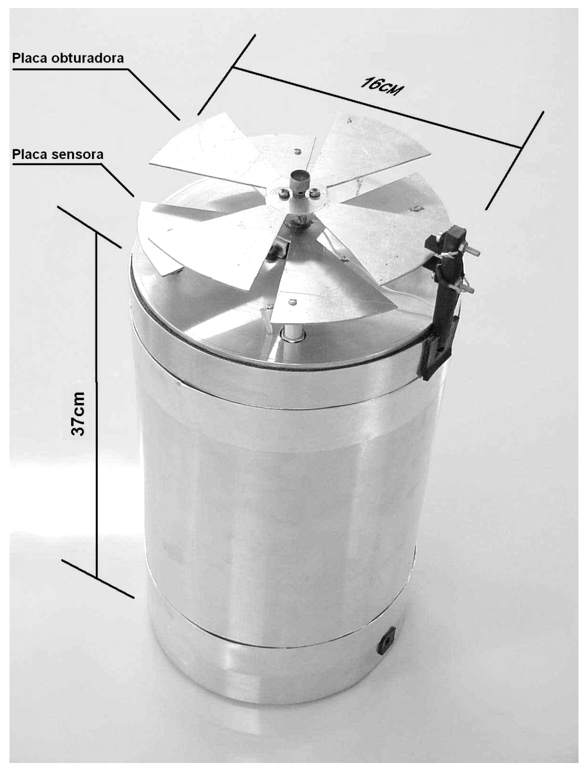

Fig. 3 - View of the field mill prototype.

Inside the sensor, there is an ordinary AC motor (127V / 60Hz) that produces 3600 rpm which dimensions are reduced. This motor was mounted into a metal box to guarantee the isolation from the electromagnetic noise produced by the motor. Besides it, there is the basic electronics responsible to capture and amplify the signal provided from rotating sensor electrode.

The acquisition sensor is composed by three blades, as shown in figure 4. In this figure it is possible to see some details about the rotating sensor electrode and the sensing electrode.

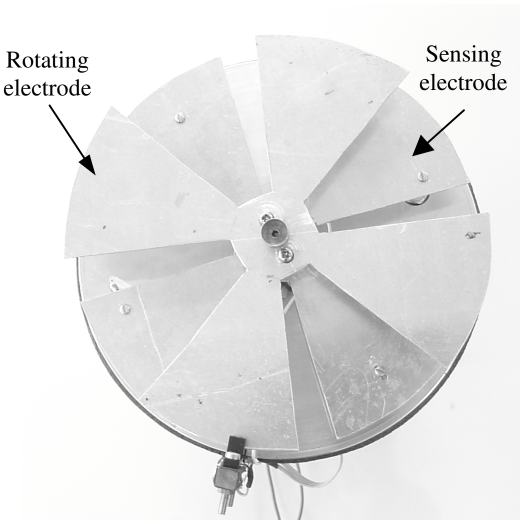

Fig. 4 - Construction details of the sensor electrode (top of the field mill prototype).

Because the sensing electrode is exposed to the electrical field, an alternating current flows in the output circuit. The magnitude of the generated current and hence the field, is related to the charge as well as the speed of rotation. Then, through an amplifier, the current that comes from the sensor is converted to a proportional voltage, being manipulated.

Figure 5 shows the block diagram of the electronics used in the proposed system.

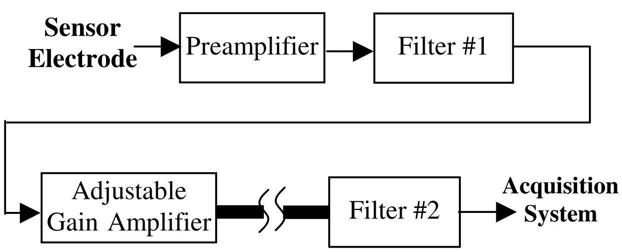

Fig. 5 - Electronics block diagram of the field mill prototype.

A waveform is obtained on the output sensor electrode with frequency of 240Hz, being proportional to the applied electric field. Since the waveform is around ten of millivolts, it is important to mention that the preamplifier input has a very high impedance.

The signal provided from the first amplifier brings some noise. Then, to minimize the noise ratio were used one active filter (filter #1) to let pass only the frequency of 240 Hz, resulting in a good low frequency rejection.

The sensor calibration is an amplifier (Adjustable Gain Amplifier block) which gain can be adjustable according to the signal intensity measured. This circuit is very important since it is responsible for the correct calibration of the field mill prototype, as it will be described later.

In the prototype output is connected a coaxial cable. Then, the signal is injected in another filter being 4^{th} order Low Pass (filter #2) on the input of the acquisition system to block any high frequency noise that could be inducted on the cable. Then, the acquisition system receives is a specific circuit (Pico Scope - it is a kind of oscilloscope designed for use with a personal computer) that converts the waveform measured, allowing the investigation and analysis through the computer.

Another sensor developed is a flat-plate. This sensor is also connected in the electrical monitoring system in order to obtain more details about the lighting captured. Figure 6 shows its block diagram.

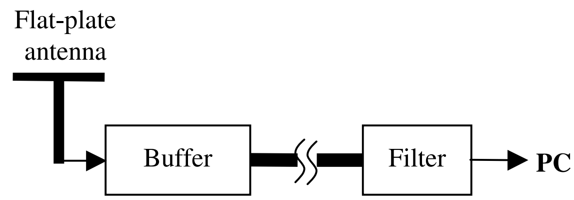

Fig. 6 - Electronics block diagram of the Flat-plate sensor.

Besides the electric sensors, as shown in figure 2, it was also developed a video camera network, which consists of cameras with continuos records and record data activated by movement, where it is possible to obtain images of cloud-to-cloud lightning flashes and cloud lightning flashes recording 30 frames per second. One of these cameras is linked to a mirror that allows 360 degrees of vision.

These images allows us investigate with more details the discharges observed and compare with the data obtained from the flat-plate and field mill and also, to realize comparisons with RINDAT network (Rede Integrada Nacional de Descargas Atmosféricas). These comparisons are responsible to validate all data observed in our electrical meteorological monitoring.

3 CALIBRATION AND RESULTS

The instrument calibration is a fundamental parameter to take in consideration before doing any measurement. Due to this, studies were done in order to obtain an electric field closer to the ideal. As a result, it was observed that it is possible to obtain a quasi linear electric field by a capacitor composed by two plain and parallels metal sheet, as described in the literature [4].

To calibrate the field mill prototype it was built a two large parallel surfaces being almost 10 times bigger than its diameter producing a very linear field. To reduce the "edge effect", the distance between both metal sheets is around few centimeters.

The distance between the metal sheets is adjustable. To calibrate the proposed field mill it was used a variable DC voltage source (0 to 500V), where it is possible to reach fields of about 10kV/m. This is a very realistic way to calibrate the sensor.

After doing some experimental calibrations, it was observed that the signal variation was very linear. The sensor calibration was fixed in 1.0 V_{peak} to represent 1kV/m.

3.1 Data acquisition and experimental results

As described previously, it is necessary use a digital instrument (Pico Scope) which one is similar to a digital oscilloscope for Personal Computers. The instrument sample rate used in the proposed system to acquire all experimental data is 100MS/s.

To analyze the field mill experimental data were used a specific software installed in a PC supported by "Windows" operational system. The data acquire from field mill and the flat-plate were done using *PicoLog Recorder*, which one is a kind of oscilloscope, where there are typical functions such as trigger, cursor, timebase etc.

Figure 7 presents some experimental results concerning to field mill and flat-plate obtained during one thunderstorm in São Bernardo do Campo city. These results are in agreement with the literature [5-8].

On the other hand, since the data acquisition is done 24 hours per day during 7 days per week, it was necessary to develop a tool that can read and store all data from the both sensors. This tool allow us get all experimental data and analyze it with more details. The interface of this software is shown in figure 8. Note that this software allow us observe the experimental with details, due the “x” axis (time) being in milliseconds.

Figure 9 shows some video captured images from one thunderstorm. In these pictures it is possible to observe some details from the lightning.

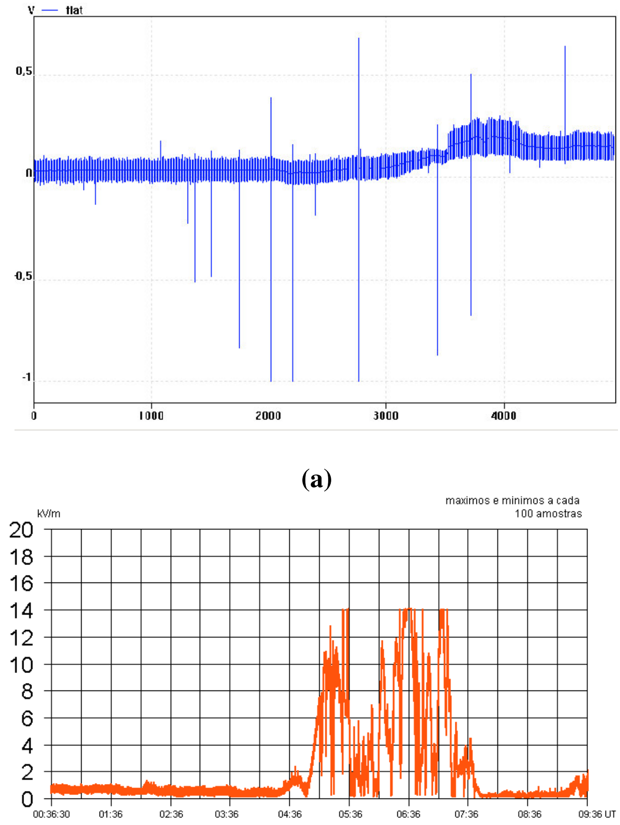

Fig. 7 – Experimental results obtain through the (a) flat-plate and (b) field mill during one thunderstorm.

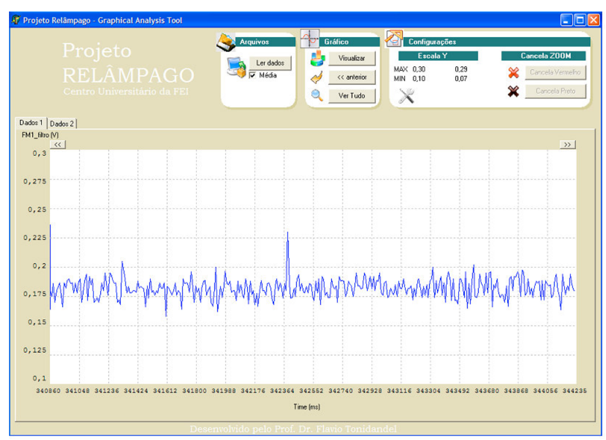

Fig. 8 - Experimental data example using the software developed for acquisition and evaluation of all experimental data.

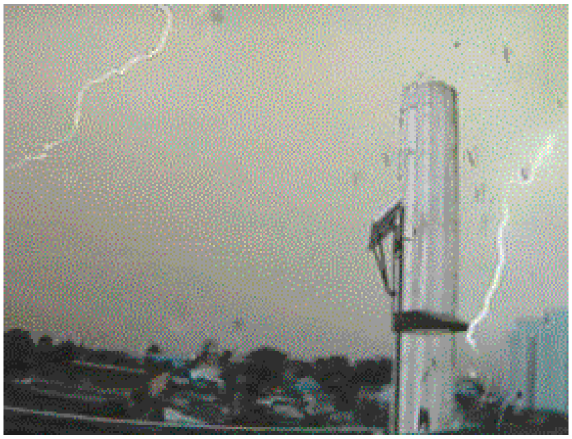

Fig. 9 – Real images captured from the lightning during one thunderstorm.

4 CONCLUSIONS

This paper gives the measurements results obtained from the electrical meteorological monitoring conditions in São Bernardo do Campo, besides the description of a new system developed to realize these studies. The next step of this work is to develop a new field mill sensor in order to improve its configuration.

5 ACKNOWLEDGEMENT

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