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Data Acquisition System for Volcano Monitoring With Real-Time Transmission, Low Cost and Low Power Consumption

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***Abstract* – An acquisition system has been developed as an evolution of the gDT316 and gCNT16 dataloggers [1]. This new datalogger, gDT524, has several advantages in comparison with the previous versions. The main features, beside the low power consumption and low cost, are: an A/D converter with 24 bits five-channels inputs, two 16 bits counters, meteorological sensors, real time clock with synchronization over NTP, micro-SD storage and GPRS communications through any standard modem with AT commands. Here we describe this device, developed in order to acquire low rate parameters related with volcano activity.**

***Keywords* –volcanic monitoring, dataloggers, time synchronization**

I. DESCRITION

To monitor the status of a volcano or a volcanically active area is important to use different techniques to achieve adequate monitoring [2]. In addition, data generated by different techniques should be treated as a multidisciplinary network. Normally, a volcano monitoring is performed using three main techniques, such as seismology, geodesy and geochemistry, but other techniques studying other parameters are also used such as gravimetry, geomagnetism, thermometry, etc. [3, 4]. The installation of this instrumentation is usually located in areas of difficult access and in harsh environments. All these factors constrains the sensors systems installed in these areas have to be robust and energy efficient. Moreover, for volcanic monitoring, it is very important to provide real time data transmission that makes the price of these equipment’s very high.

The Nacional Geographic Institute (IGN) is responsible of the volcano monitoring in Spain since 2004. With this challenge, and the background experience of the group, IGN decided to produce its own dedicated geochemical instruments.

This system has been designed to measure parameters that could help us understanding the inner processes taken place in a volcanic area such as soil temperature, atmospheric pressure, CO2, RN222, rain, etc.

A. Components

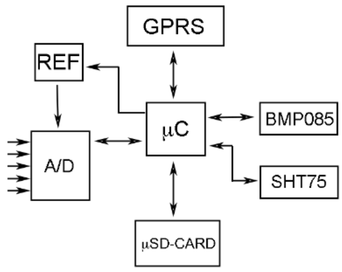

Figure 1. Schematic of the datalogger

The main characteristics of gDT524 (block diagram in Figure 1) are: five 24 bits channels, one 10 bits for battery logging, two input pulse counter, two meteorological sensors (BMP085 and SHT75), μSD storage, internal real time clock with NTP/GPS synchronization capability, TCP or UDP connection for transferring data, programmable sampling rate and sensor´s preheating time.

B. Operation

This device remains most of the time in “sleep mode” for low energy consumption and wake up for data acquisition and transmission, as well as time synchronization over NTP.

The gDT524 datalogger is able to shut down all sensors and communications and re-activate them in a programmable time lapse. When the buffer fills up, the data is transferred to the SD card and is transmitted over GPRS to the data center. Periodically, the RTC of the microcontroller is synchronized using the Network Time Protocol in order to maintain an accurate time. The measurement of low evolution rate parameters, a very accurate time is not necessary but in situations where you have to leave a sensor during a long time period, time synchronization is needed.

This device has several options and programmable parameters, the main ones are:

- Sampling rate is programmable from seconds to hours. Also, an oversampling mode is possible in order to improve the signal in some situations, making a low pass filter over input signal
- From the point of view of the data acquisition, it can be programmed the name of the station, channels, counters, preheating time, calibration curves, resolution and meteorological sensors
- From the point of view of data stored, it can be downloaded over serial or GPRS with a software made for this purpose
- From the point of view of communications, it can be programed the server IP and port for transferring the data, and the NTP server for time synchronization.

All these features can be accessed through a kind of UNIX terminal, simulated by the microcontroller, supporting some UNIX commands such as 'rm', 'cat'.

C. Power consumption

Actual consumption of the device is given in Table 1, measured with a DMM916 Tektronic multimeter [5], using a 12V battery for power supply.

MODE	gDT524(mA)@12V
Sleep	0.4mA
Transmitting	10mA
Sync (NTP)	6.5mA

Table 1. Power consumption of gDT524 datalogger

These consumption values assure a long autonomy for the equipment.

D. Price

Costs of each devices are shown in Table 2, calculated form prices for each component provided by RS (international electronic component reseller) [6], while PCB manufacturing costs were given by PCBCART (Professional China Portotype PCB Manufacturer) [7].

gDT524			
Component	Units	Price	Total
Microcontroller	1	6.24	6.24
A/D Ref	1	3.20	3.20
A/D Converter	1	8.48	8.48
SD-Slot	1	3.06	3.06
SD-Card	1	4	4
PCB Manufacture	1	3	3
SIM900 GPRS	1	11	11
BMP085 (Pressure sensor)	1	10	10
SHT75 (Humidity sensor)	1	29.50	29.50
		Total (€)	**78.48**

Table 2. Datalogger prices

II. RESULTS AND DISCUSSION

Energy consumption is really low, is less than 1mA @ 12V in sleep mode and 10mA @ 12V in transmitting mode. The fact that this device are own designed, their low cost and the necessary components for their assembly can be purchased at any electronic component reseller, allow quick deployment of different types of geophysical and geochemical networks, facilitate their maintenance, as well as a potential improvement in its design.

The first implementation of this system is the monitoring of a fumarolic area of Teide Volcano summit crater. The sensors that we employ for this particular application are temperature sensors, located at different depth in order to study the soil heat flux [8]. Also, atmospherics parameters such as atmospheric pressure and humidity are acquire in order to improve the interpretation of data.

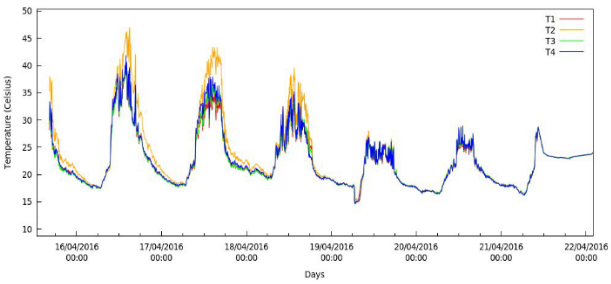

Figure 2. Data plot of a system test during one week

Figure 2 details a week of system tests before it has been installed in the fumarolic area of Teide Volcano summit crater. Also, the figure shows the day and night cycles of four temperatures, which have a noise level below a decimal degree.

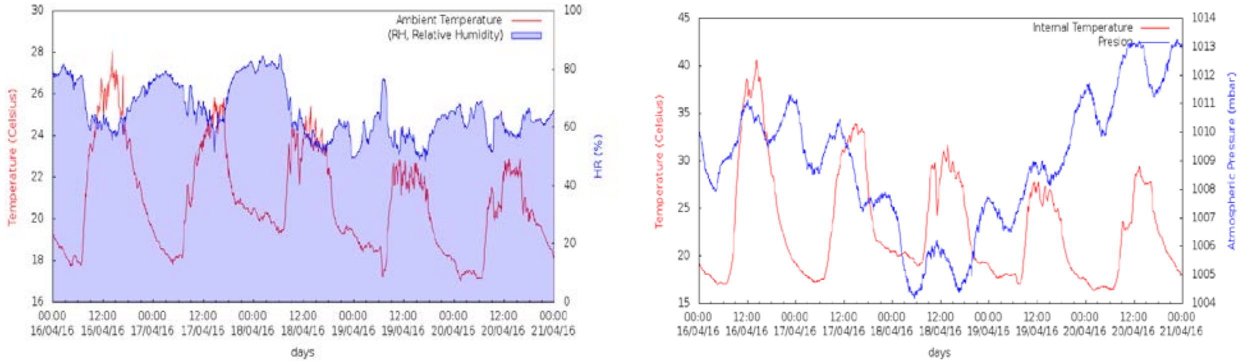

Figure 3 Data plot of a system test during a period of one week. On the left humidity with its own temperature sensor, on the right atmospheric pressure with its own temperature sensor

In Figure 3 are shown the pressure and humidity measurements (with their respective temperature sensors of) in the same period. The characteristics of these sensors are sufficient to meet the needs of these applications.

III. CONCLUSIONS

The system described in this paper allows measurement of signals with a high degree of resolution. It is possible to measure the temperature with a noise level well below a decimal degree which is very important to keep track of the changes of a volcano or a volcanically active area. In addition, because the system incorporates the possibility to measure meteorological parameters such as: pressure, humidity and rain it allows the correct interpretation of temperature data.

The low power consumption, even with real time data transmission, permits the systems to run for months only with batteries, which allows installation in areas of difficult access.

Low power consumption increases the autonomous operation and minimizes battery shifting. Low cost design allows a high density sampling network along with the fast maintenance and substitution (if the case).

IV. ACKNOWLEDGMENT

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