EARTH SCIENCES
RESEARCH JOURNAL

Earth Sci. Res. J. Vol 8 Nº 1 (Dec. 2004): 52 - 55

OSSODAS, A PORTABLE DIGITAL SYSTEM FOR SEISMOLOGICAL SIGNAL ACQUISITION

Pedro Riascos[1], Andres Racines[2], Jhon Caicedo [3], Jorge Mejia[4] & Hans Meyer [5].
e-mail address: pepar@osso.org.co -

Observatorio Sismológico del Sur Occidente – OSSO/UV - Universidad del Valle, Facultad de Ingeniería
Corporación OSSO - §WWW:http://www.osso.org.co E-Mail:corposso@osso.org.co Tel : 57(2)6821078, 57(2)6827662 Fax: 57(2)6821078, 57(2)3313418 Cali - Colombia - Sudamérica

ABSTRACT

This paper presents the concept and design of a digital system to record seismological signals. The hardware and software designed has been interfaced to the PC 104 BUS architecture in order to achieve a modular system to acquire, process, record and transmit seismic data by telemetry. The modularity of this system offers independence technology from the manufacturers of this kind of equipments both in hardware and software, also because the system was developed under the Linux operating system GNU, which allows easy update of hardware; the software is an open platform developed in C, which allows the user to configure the system to operate online and updating according to needs.
In brief, we propose in this paper a system design option for seismological instrumentation, which presents significant advantages also for other regions and countries with high seismicity and needs of earthquake monitoring, but have serious limitations in acquiring and maintaining commercial systems imported from developed countries.

Key Words: seismology, instruments, OSSOdas, PC104, Linux GNU, spread spectrum

RESUMEN

El artículo presenta el diseño de un sistema digital para registrar señales sísmicas. El hardware y software diseñado son adicionados a la arquitectura de BUS PC/104 con el propósito de tener un sistema modular para adquirir, procesar, almacenar y transmitir datos sísmicos por telemetría. La modularidad de este sistema ofrece independencia tecnológica con los fabricantes de estos equipos tanto en hardware como en software, ya que el sistema fue desarrollado bajo una plataforma Linux GNU que permite al usuario configurarlo o modificarlo de acuerdo con sus necesidades
En conclusión, proponemos una alternativa de sistema para la instrumentación sismológica, el cual es ventajoso para aquellas regiones con alto grado de sismisidad, necesidad de equipos para instrumentación sismológica, severas limitaciones para adquirir y mantener sistemas importados de países desarrollados.

Palabras clave: Sismología, OSSOdas, Instrumentación, PC104, Linux GNU, espectro disperso

Manuscript received July 2004
Paper accepted Octubre 2004

INTRODUCTION

Presently there is an increasing number of portable field system for seismic data acquisition available on the market, with high dynamic range, high data recording capacity and with Ethernet and radio connectivity; these gave many seismological observatories the opportunity to improve the observation of seismicity, including observatories in Colombia, but with the disadvantage of high costs for maintenance, repair and updating, as well as dependency of a single provider, (i.e., the manufacturers abroad).

On the other hand, commercially available seismological instrumentation typically is expensive, rather specialized, predominantly built with proprietary hard and soft components, and very difficult to keep in a good condition. Besides overcoming these disadvantages, it is also our aim to further our capacities in scientific instruments design and construction.

Taking this into account, it is necessary to develop our own seismology instrumentation equipment, with state-of-the-art design but at very low manufacturing, operation and maintenance costs, and transparent to the user, so that they could easily be adapted to specific needs, but also looking for the possibility of upgrading it with the lowest possible expenses.

System description

The digital acquisition system has been provided with six analog input channels available for instrumentation, which can be connected to two sensors (i.e., a tri-axial seismometer or 3-components accelerometer). The signals are conditioned with a programmable gain amplifier and low pass filtered to 250 Hz in order to avoid aliasing effects. A 16-bit A/D converter is used to sample the amplified and filtered signals. The digitized data is processed with a digital filter developed for a wide range of frequencies, programmable by the user [1]. The processed data are stored locally and can be accessed online by radio through a serial or Ethernet interface. In applications where online acquisition is not required (i.e., the equipment is a standalone station), the data is recorded on a hard disk and downloaded periodically.

The user can access remotely, initialize and check the operation of the system, load and observe the acquired data and update the software and recording parameters used for acquisition. The system uses a 40 Gb hard disk, which allows one month of continuous recording at 1000 samples/second using 3 channels, or eight months of continuous recording at 125 samples/second. In applications where data transmission (radio, Internet, etc.) is used, the hard disk will not store until its maximum capacity because there is a stored option to erase data once have been transferred a high volume of data by telemetry into a data collected station.

Hardware description

The acquisition system includes a signal conditioning stage, a power card to supply ±12 and 5 VDC to the signal conditioning stage, an internet card for communication with an external network, an 8 serial port card to connect the GPS system and a spread-spectrum two-way radio, a 16bit A/D converter, and an interconnection card to access the external devices.

The signal conditioning stage was designed with a programmable gain amplifier, to amplify the signal supplied by the sensor with a gain range from 1 to 8000 (i.e., 80 dB), and input impedance of 10 E 10 ohm || 6 pf. To avoid aliasing effects during the digitisations; a 6^{th} order Butter worth low-pass analog filter with a cut-off frequency of 250 Hz was added t- this stage.

The 16 bits A/D converter has 8 differential or 16 single-ended inputs, with a maximum sampling rate of 100 Ksps, 96 dB of resolution, and programmable gains of 1, 2, 4 and 8. The maximum input voltage of the converter is ± 10 VDC for a linear operation. Figure 1 shows the block diagram of the system as well as the signal conditioning stage.

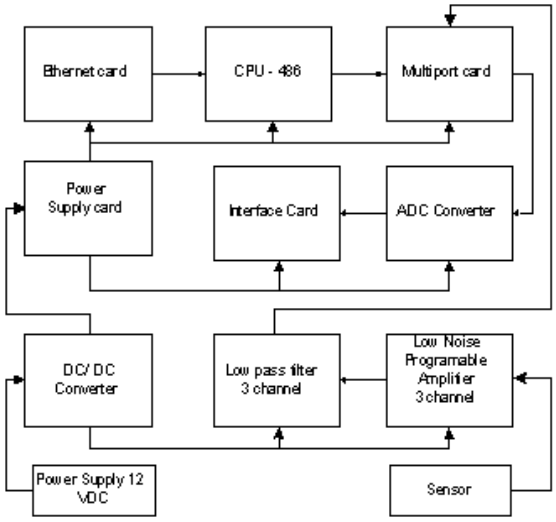

Figure 1: Block Diagram Of The OSSOdas Acquisition System

THE OPERATING SYSTEM

The acquisition system was developed under the Linux operating system GNU, which is distributed according to the open source model where the programmers are free to adapt the source code for custom purposes. The actual configuration uses a CPU with the following features [2]:

- Host platforms supported: Redhad Linux 7.3
- Processor: 2X x 86
- Clock speed: 100 MHz
- Memory: 32Mb SDRAM SODIMM Module
- Power supply: ATX, 250Watt
- DEV104+, Bus extender board (PC/104+ to 2-slot ISA and 2-slot PCI backplane)
- MZ104+, PC/104 Board with Dual Ethernet

Additionally, the programs to acquire, record, and transmit the signals are written in C under Linux and they are included in the following modules:

- Automatic data acquisition
- GPS Configuration
- Data processing and storing
- Network configuration
- Time synchronization

FEATURES AND APPLICATIONS

The system designed has the following features:

- Real-time acquisition of seismic signals
- Remote monitoring
- GPS time synchronization
- Two 3-channel analog inputs
- 16-bit digital output
- RS232/Ethernet connectivity
- Telemetry access (Spread spectrum)
- Removable hard disk data storage
- 176 dB full dynamic range
- 80 dB user selectable analog amplifier
- 96 dB digital output
- Programmable sample rate up to 1000 sps
- Weather sealed housing (for hostile environments)
- Rapid deployment by unskilled personnel

The OSSOdas system can be used in applications such as:

- Measurement of environmental noise
- Seismic signal monitoring
- Seismic profiling
- Bridge and building monitoring
- Passive Seismic Monitoring (oil fields)
- Quarry blast vibration control
- Strong motion seismology

TECHNICAL SPECIFICATION

At full operation, the system requires 1.8 A, which could be supplied with a 12 V, 100Ah battery and two solar panels of 80W. The system is enclosed in a hermetically sealed Pelican PFV case to operate under outdoor conditions. All connectors for accessories of the system are circular plastic connectors AMP. The sensor used with the system is the electronic Lennartz LE3D-light which has a natural frequency of 1 Hz and bandwidth of 80 Hz [3], although the user can use sensors from different suppliers. Figure 2 shows the OSSOdas layout and Table 1 shows the OSSOdas physical characteristics.

Figure 2: OSSOdas layout

*Table 1:*OSSODAS PHYSICAL CHARACTERISTICS

Description	
Size	415 X 330 X 175 mm (width X depth X height)
Weight	5 Kg
Case type	Pelican PFV
Operating temperature	-40 to 85ºC
Sensor unit	97 mm diameter, 68 mm height

CONCLUSIONS AND FUTURE WORK

A low cost digital system for seismic signal acquisition has been developed. The system allows acquiring, process, record and transmitting seismological data by telemetry. In brief, we propose a system design option for seismological instrumentation, which presents significant advantages for other regions and countries with high seismicity and needs of earthquake monitoring, as well as serious limitations in acquiring, and maintaining imported commercial systems.

The system reliability was checked stage by stage, that is, all of the measured values correspond with the experimental results by validated systems. The stages that were verified are: the signal conditioning, the acquisition card, time accuracy, and the digital signal processing.

The future work will be focused on the design of digitally configurable analog gains, allowing the user to select the gain directly from the software, and design of analog and digital filters using programmable circuits [4]. This technology allows configuring the system in a wide range of frequencies, from 1 to 1000 Hz. Also, the future work will aim at decreasing the power required by the system in order to operate at low current. This is possible due to the availability of solid-state storage (i.e., disk on chip and compact flash card), which allows sharing the operating systems and acquisition process with the hard disks during the operation of the system.

REFERENCES

Diamond System Corporation, 2002. “Rugged Embedded Solutions for Harsh Environments and Mobile Applications”.

S. W Smith, (1999) “The Scientist and Engineer Guide to Digital Signal Processing”. California Technical Publishing San Diego California, Second Edition.

“LE-xD Geophone Family”, Document Number 990-0003, Lennartz Electronic, Email: info@lennartz-electronic.de

“Programmable Analog Circuits”, isPAC Handbook, Lattice Semiconductor Corporation, January 2000.

E. Freaking, (1997). “Digital Signal Processing in Communication Systems”, Chapman & Hall, New York, NY.

F. Scherbaum. (1994) “Basic Concepts in Digital Signal Processing for Seismologists”, Springer-Verlag.