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A DIGITAL ACCELEROGRAPH RECORDING SYSTEM FOR INSTRUMENTING STRUCTURES

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ABSTRACT

The *Digital Accelerograph Recording System for Structures* (SADE), is a digital data acquisition network that records acceleration data about the behavior of structures during earthquakes. The system was designed and developed at the *Centro de Instrumentación y Registro Sísmico* (CIRES), using microcontrollers, a fiber optic communication network and credit card solid state memory storage. The SADE can be operated by means of a notebook computer. It was designed with few mechanical elements giving more reliability and the advantage of little servicing, besides that the operating cost is low. Data gathered from the structure under study may validate design factors and help to improve the building design regulations currently in use.

KEYWORDS

Building seismic instrumentation; Fiber optic communication; Low cost instrumentation;
Seismic Accelerograph.

INTRODUCTION

In order to enhance the knowledge about the dynamic performance of structures during real earthquakes excitations, some type of mathematical model calibration is required. Actual data gathered from the structure under study may validate design factors and help to review the building design regulations in use. (Murià *et al* 1993, Ordaz and Singh 1992, Prince 1988).

DESCRIPTION

The SADE consists of the *Sensor Unit* (ESTSEN) with up to 16 points and one *Central Recording Unit* (CENREG) interconnected by a digital network based on fiber optic with high velocity data transmission, as shown in Fig. 1. The system measures synchronously in real time, the accelerations induced by earthquakes on the instrumented structure and stores the information obtained in a central memory with high capacity and low energy consumption. It has an internal clock; nevertheless, it accepts external time code from one additional source such, as the WWV, the OMEGA navigation system or a Global Position

System (GPS); this additional time code is recorded together with the acceleration data. All functions and operating parameters may be visualized and changed through a notebook computer. The stored data may be retrieved using the computer or interchanging the memory card. A typical distribution of the system on a three level building is shown in Fig. 2.

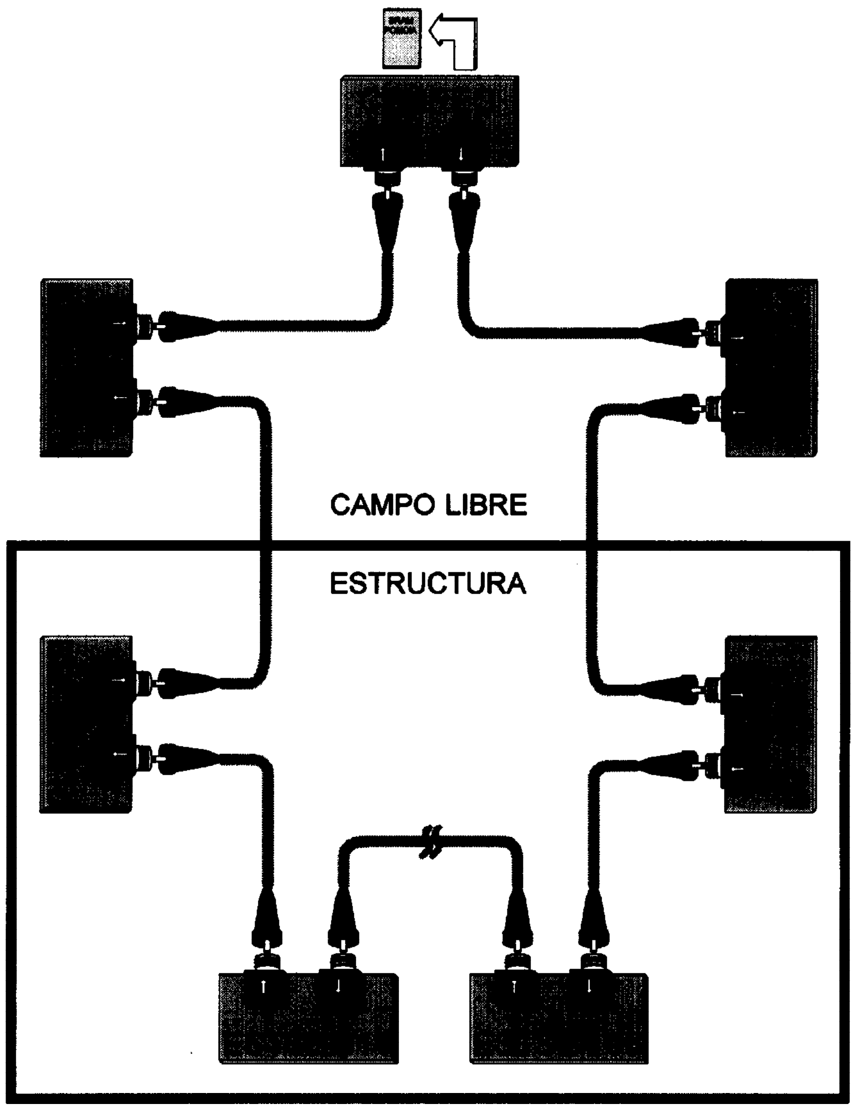


Fig. 1. Communication network diagram of SADE

Sensor Unit (ESTSEN)

The *Sensor Unit*, see Fig. 3, consists of data acquisition system that measures the acceleration in three spatial axes. Signals are obtained from a capacitive triaxial accelerometer sensor, and conditioned by a digital controled analog interface, providing low-pass filtering, amplification and offset correction.

The resolution of the A/D converter could be selected from 10 or 12 bits, depending on the requirements of the system. The digitized information is taken by a microcontroller and temporarily stored on a buffer until the *Central Recording Unit* request for it. At the same time the microcontroller calculates long and short time averages for an additional adjustment of the signal offset and for trigger thresholds used for event detection.

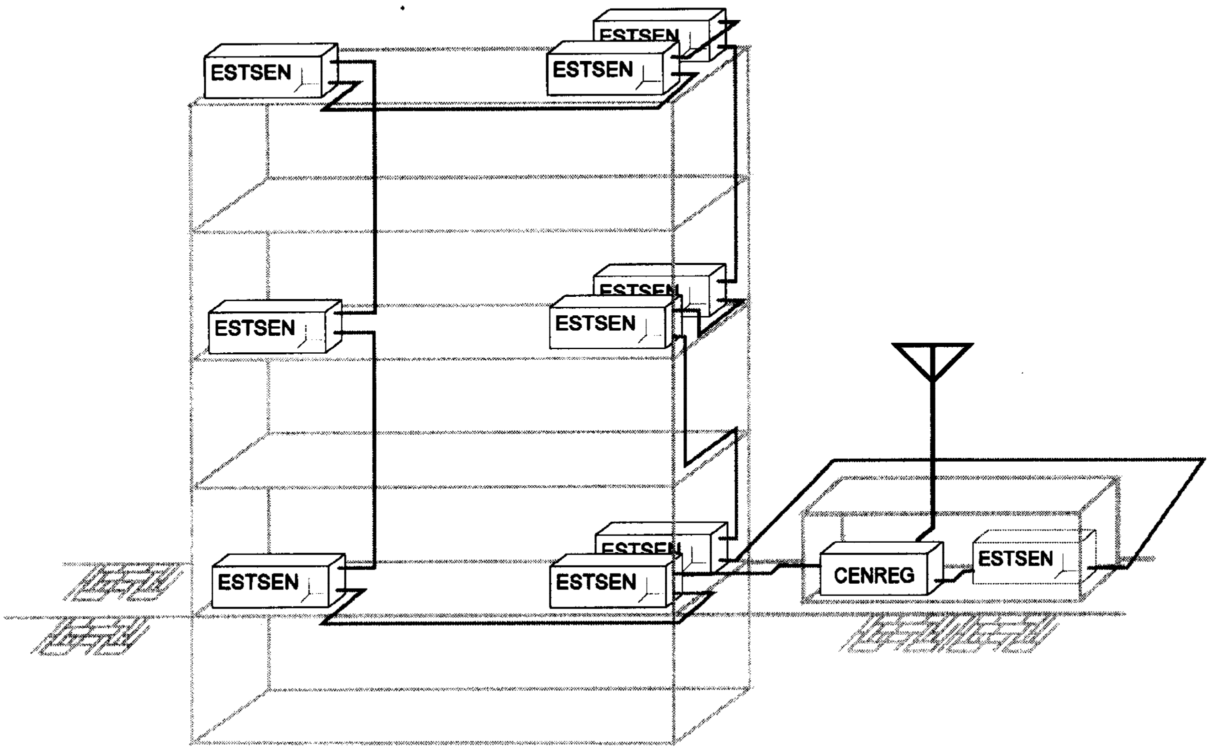


Fig. 2. Typical distribution of SADE on a three level building

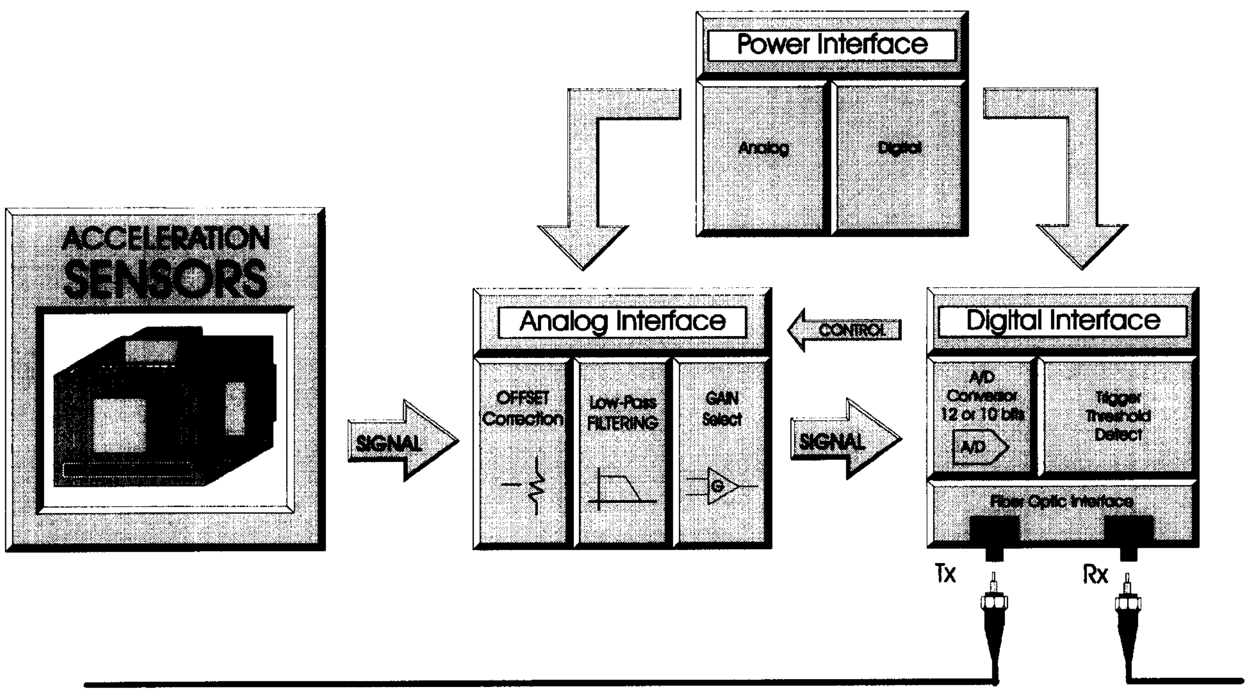


Fig. 3. Block diagram of Sensor Unit (ESTSEN)

Central Recording Unit (CENREG)

The *Central Recording Unit*, synchronizes, receives and stores in a temporary circular buffer the information transmitted by the *Sensor Units*. The system is triggered by an automatic threshold detection, an external trigger input or by an electrical signal coming from the Seismic Alert System of Mexico City (Espinosa *et al.* 1995). In any case, the CENREG starts storing data on a PCMCIA standard SRAM memory card with battery backup. If a power or general failure occurs, the memory card retains data for more than one year, so the Central Recording Unit could be considered a black box, like the one used in airplanes. The CENREG should be installed inside of a robust protection or outside of the area that could collapse.

The system is operated by software developed for this purpose in CIRES. It runs on a notebook computer interconnected to the CENREG by the parallel port for fast communication. The program takes the control of the system and all operation parameters are shown and could be changed by the operator. These parameters are: identification of the instrument, date, hour, sampling rate, pre-event and post-event times, selection of type of trigger, turning on or off of *Sensor Units* and other parameters. The program can also display parameters of the Sensor Units and permits to change them. Some of these parameters are the range of the accelerometer sensors, the gain of the channels, the trigger thresholds and the enabling or disabling of a particular axis. The program shows in real time the signals from the accelerometers in many different amplitude and time scales.

Using the Control Program is the best way to capture the information of events recorded on the memory of the system. It saves the events on its own format, but it has options to transport them to Terra and ASCII formats. In addition, this software may display and print on a printer the acceleration graphics in many different time and amplitude scales, the amplitude could be also shown in different units like A/D counts, gals and m/s^2, and time in seconds. Some of the processes that the program is able to do are: The Fast Fourier Transform and power spectra, digital filtering and Transfer functions between any two points of the structure.

RESULTS

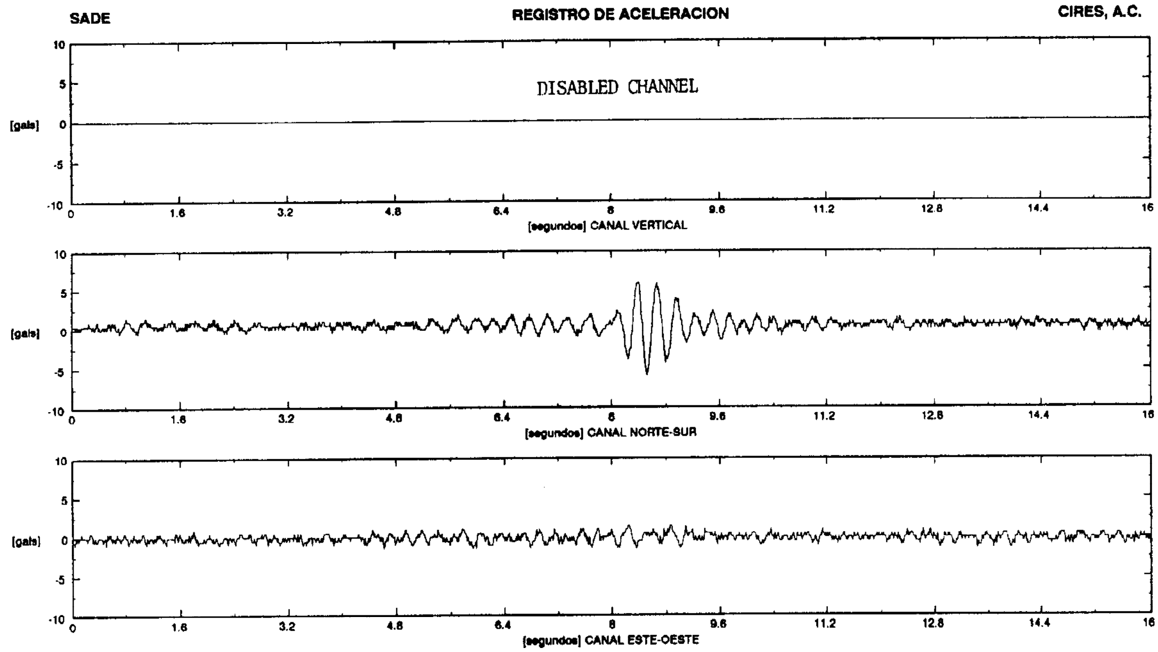
A prototype system is installed on a four level building in Mexico City. Ambiental noise events have been recorded, as shown in Fig. 4, and one Mw 7,5 earthquake occurred on October 9, 1995 with epicenter at Colima State coasts, as shown in Fig.5.

Nowadays the system is under evaluation to instrument some new buildings in Mexico City; several industrial structures as thermoelectric plants; as well as dams, and bridges.

Its versatile design allows its interconnection to other types of sensors, so it can be used in other applications like monitoring of gas, temperature or strain. An example of application could be a telemetry systems used in meteorology studies.

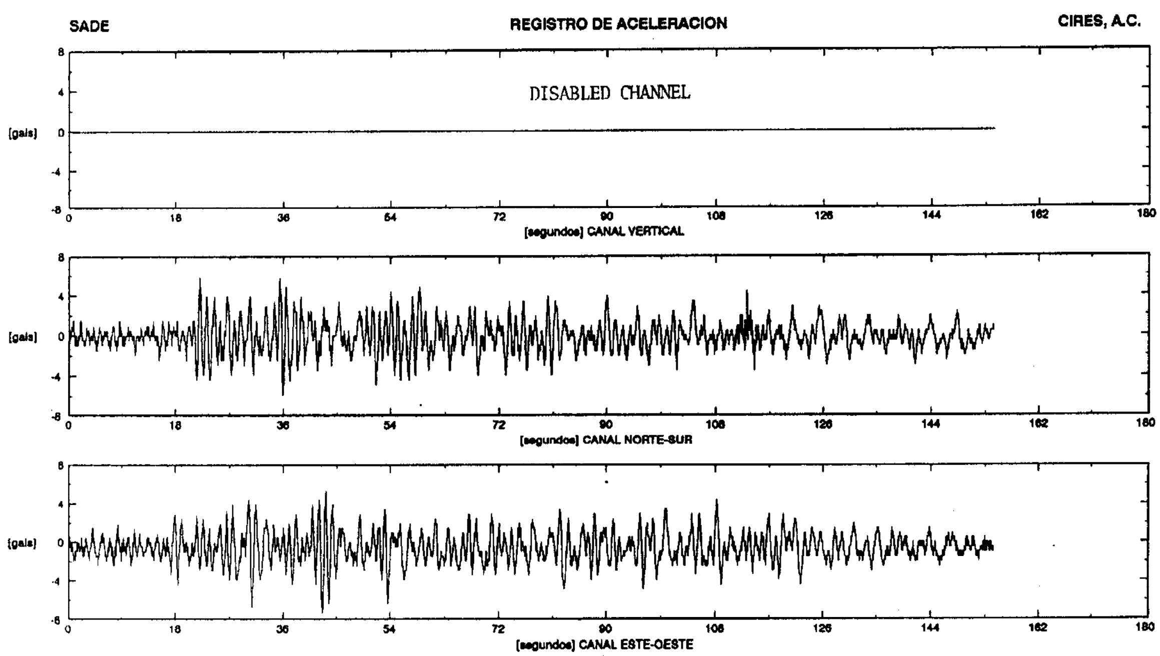
CONCLUSION

Comparing the SADE with others systems used for strong motion instrumentation in structures, we have observed that it has some advantages, some of them are: the sampled acceleration data is perfectly synchronized, this helps to have more precise studies of the dynamic characteristics of a structure; an easy way to match the several strong motions instrumentation needs; easy of maintenance and operation of the system; and lower price.



Archivo:	XEN00050.287	**EstSen:** 1	**Nivel:** Azotea	
Hora:	16:25:20 GMT 10:25:20 Local			
Fecha:	14/10/95 GMT 14/10/95		**Máximo [gals], [segundos]**	**Mínimo [gals], [segundos]**
Estación:	5	**VERTICAL**	0.00, 0.00	0.00, 0.00
Nombre:	SADE CIRES,A.C.	**NORTE-SUR**	5.86, 23.35	-5.86, 23.49
Ubicación:	Anaxágoras 814	**ESTE-OESTE**	1.46, 23.21	-1.46, 19.61

Fig. 4. Ambiental noise event recorded by SADE



Archivo:	XLC00052.282	**EstSen:** 1	**Nivel:** Azotea	
Hora:	15:33:04 GMT 09:33:04 Local			
Fecha:	09/10/95 GMT 09/10/95		**Máximo [gals], [segundos]**	**Mínimo [gals], [segundos]**
Estación:	5	**VERTICAL**	0.00, 0.00	0.00, 0.00
Nombre:	SADE CIRES,A.C.	**NORTE-SUR**	5.86, 21.91	-5.86, 35.71
Ubicación:	Anaxágoras 814	**ESTE-OESTE**	5.37, 42.98	-7.32, 42.48

Fig. 5. MW 7.5 earthquake, occurred on October 9, 1995 with epicenter at Colima State coasts and recorded by SADE in Mexico City

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