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AUTOMATIZED EQUIPMENT FOR AMBIENT VIBRATION MEASUREMENT AND PROCESSING

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SUMMARY

At this paper, the equipment and results of a measurement realized to obtain the fundamental period and the uncertainty of a structure is shown.

An incipient research group in Autonomous University of Baja California (Ensenada, Mexico) designed and built an automated equipment to study structures using ambient vibration like excitation source.

The equipment can register and process data. It is formed by a laptop, a data acquisition card and an accelerometer set. Furthermore, software was developed to realize specific tasks. A goal of the software implemented is the next: beside conventional Fourier analysis, the processing includes a statistical treatment to obtain measurement with uncertainty or error associated. The equipment is portable and the information is processed in the field.

INTRODUCTION

There is a need for continuous evaluation of the level of performance and safety of structural systems in the power, civil and aeronautical engineering areas when subjected to earthquake, hurricanes and other extreme loads. Several methods have been developed in recent years for structural damage evaluation, many of which require of destructive tests or a complex process with finite element. For practical applications, these methods have been shown to be ineffective because of labor intensive tuning, additional damage in the structures, excessive computational effort, and significant uncertainties caused by user interaction and modeling errors.

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Ambient vibration tests have been used to locate structural damage and have been employed in the evaluation of the integrity of structural systems. These tests are non-destructive methods. However, in some cases, these methods require a equipments, which it have a high cost, or a special training is required to handle them. Therefore, ambient vibration equipment is described.

The equipment described in this paper is the first prototype built in northwest of Mexico and put the base for the Structural Dynamic Laboratory of Autonomous University of Baja California in Ensenada. This equipment will allow studying the dynamics properties of different structures as buildings, bridges, or dams. A similar prototype is pretended to build in the Electric Research Institute (Cuernavaca, Mexico) to measure the dynamics properties of electrical equipment like Power transformers, Circuit breakers, and Transformer bushings. Furthermore, the equipment has like a second objective to serve as pedagogic instrument.

EQUIPMENT

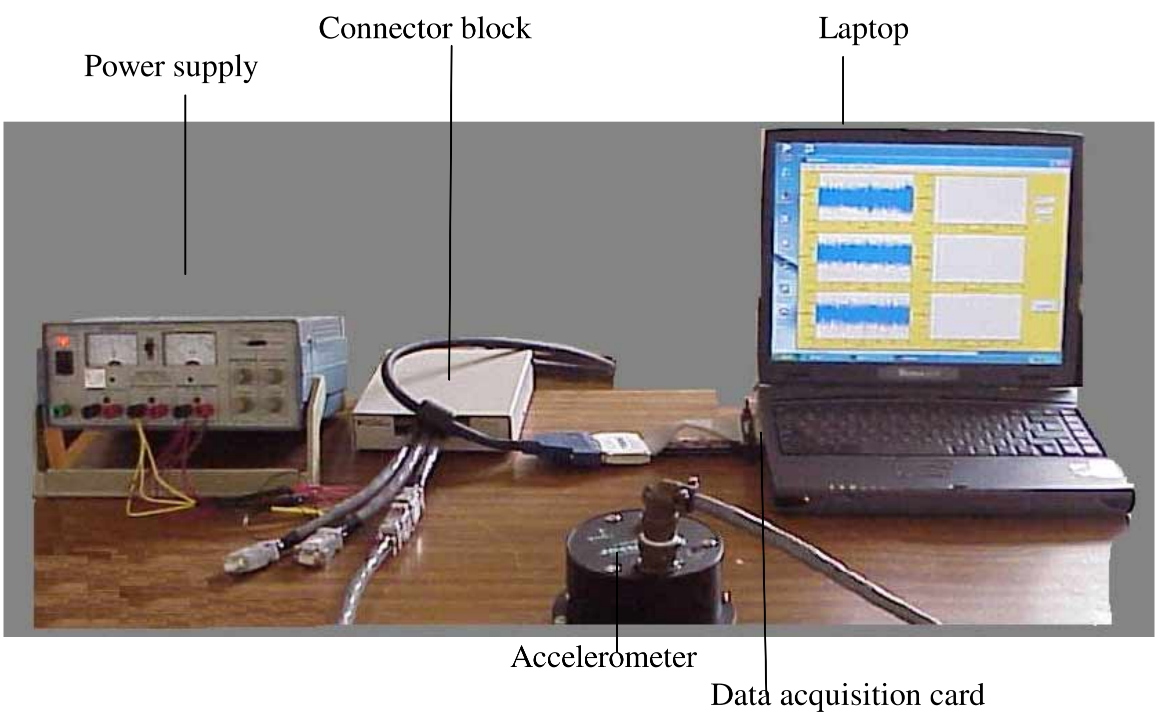

Figure 1 Ambient vibration data acquisition system.

SYSTEM CHARACTERISTICS

- 8 channels for differential inputs or 16 single-ended inputs
- 4 accelerometers of 3 components each one
- Voltage supply +/- 12 volts with option to use battery
- Robust construction, waterproof, dustproof
- 3 cables of 30, 40 and 50 m with 10.5 ohms/1000 ft
- Frequency range of 0.30 Hz to 100 kHz
- Portable, easy to use
- Save data in text files
- 3000 samples per second

Accelerometer FBA ES-T of Kinemetrics

Dynamic range	155 dB
Bandwidth	DC to 200Hz
Full-scale range	User-selectable at:± 0.25g, ±.5g, ± 1g, ± 2g or ± 4g
Full-scale output	User-selectable at: ±2.5V single-ended; ±10V single-ended; ± 5V, ±20V differential
Quiescent power consumtion	12 mA from ± 12V; 35 mA from ±12V
Housing	Watertight anodized aluminum case with leveling feet and leveling bubble.
Operating temperature	-20º to 70ºC
Connection	Single military-style metal connector
Dimensions	3’’ x 5’’
Weight	4 lbs.
Power supply	+/- 12 volts.

Table 1 Accelerometer FBA ES-T specifications (User's Guide [1])

The SCB-68 shielded connector block

The SCB-68 is connected between DAQCard by cable SH68-EP and the cables that come of sensor, these cables are connected to SCB-68 by screws. The SCB-68 has 2 areas for general use, 8 channels for differential inputs or 16 single-ended inputs. The SCB-68 is shielded, it has low-noise-ended to connection with DAQCard, the power requirement is 5V it can take power external or internal.

Data acquisition card DAQCar-AI-16-E-4

Bus	PCMCIA
Analog inputs	16 single-ended / 8 differential
Resolution	12 bits
Sample rate	500/250 kS/s
Input range	± 0.05 a ±10 V
Digital I/O	8
Counter/Timers	2, 24 bits
triggers	Analog and digital

Table 2 DAQCar-AI-16-E-4 specifications

The system is controlled for a laptop pentium 3, 847 MHz, 256 Mb ram, Microsoft XP professional version 2002. The computer registers data to 3000 samples per second using a data acquisition card and 3 accelerometers of 3 components each one. Data are processed at the computer in the field. The acceleration and Fourier spectra are showed in the Figure 2.

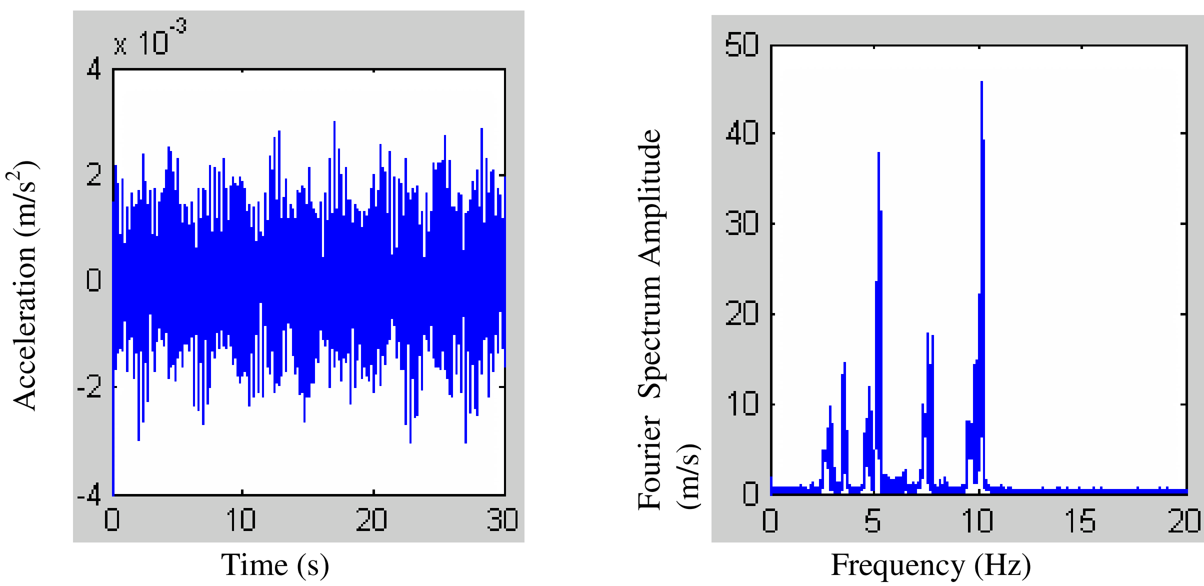

Figure 2 Measured acceleration and their Fourier spectrum in longitudinal component, at an urban bridge.

It was calculated for this measurement (Figure 2) in the longitudinal component, a fundamental frequency f_0=2.83 Hz with a spectrum ordenate A (f_0) =9.617.

Using Otnes and Enochson [2] expressions for the confidence (100 p%) limits, and a χ^2 distribution:

$prob\left[a < A(f) < b\right] = p$		
$a = \dfrac{nA(f)}{\chi^2_{n;\frac{\alpha}{2}}}$	$b = \dfrac{nA(f)}{\chi^2_{n;1-\frac{\alpha}{2}}}$	$\alpha = 1 - \boldsymbol{p}$
n= number of degree of freedom =2B_eT	*B_e= bandwidth*	*T=record length*

Table 3 Expression to calculate confidence limits (Otnes and Enochson [2]).

For a particular confidence value p=95%, B_e = 20 Hz and T = 30 s, it is calculated:

a = 7.58	b = 12.60
ΔA = (b-a)/2 = 2.51	
$\Delta A = \dfrac{dA(f_0)}{df}\Delta f$ = 2.26 Δ*f*	
$f_0 \pm \Delta f_0 = (2.83 \pm 1.11)Hz$ 95 % confidence	

Table 4 Frequency and uncertainty obtained with 95 % confidence

RESULTS

We realized measurements with the equipment and we registered acceleration data and processed them at the field obtaining Fourier spectra and a value for a particular frequency with its associated error for a specific confidence range.

REFERENCES

1. *User's Guide to EpiSensor Model FBA ES-T*. Kinemetrics. 1998. http://www.kinemetrics.com/eng_ftp/manuals.html
2. Otnes Robert, Enochson Loren. “Digital Time Series Analysis”. USA. John Wiley & Sons. 1972.