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NEW-GENERATION EQUIPMENT TOGETHER WITH METROLOGICAL PROCEDURES FOR MEASUREMENT OF PARAMETERS OF MECHANICAL VIBRATION EMITTED TO THE ENVIRONMENT BY VEHICLES

A. Lipowczan, J. Kompala, C. Bartmanski, A. Kobylecki, I. Kubik

Central Mining Institute, pl. Gwarkow 1, 40-166, Katowice, Poland

Tel.: (48)(0-32) 259 22 31 / Fax: (48)(0-32) 59 65 33 / Email: brxal@boruta.gig.katowice.pl

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ABSTRACT

Paper presents the general parameters of system destined for measurement of vibration parameters generated from communication sources. Eight to sixteen channels system was developed for evaluation of influence of vibration on buildings. The system is developed in digital technology except of the input blocks. It is dedicated for recording, evaluation and storing of vibration data. For these purposes the original software was developed. The system makes also possible the location of measurements points and aeries by using the GIS and GPS methods. This system there is in practical verification stage.

1 - INTRODUCTION

The dynamic development of road transport, and, in that, first of all, the increase of the weight of heavy vehicles, together with a worsening condition of the road surface as its consequence, have caused an increasing number of complaints from the inhabitants for adverse effects of mechanical vibration on the surroundings of transport routes, building located there and people. The investigation of the national scientific centers conducted so far and based on real field measurements were performed to a limited extent, with the use of non-standard equipment, that composed of different sets of instrumentation.

The investigation carried out by the Institute of Building Mechanics of the Technical University of Cracow, led by R. Ciesielski and E. Maciag [1], [2], [3] pointed at the complex nature of the problem, in which the theoretical description is feasible only within a limited range. The measurements are carried out in the cross – sections perpendicular to the axis of moving vehicles. The measuring transducers (sensors) are fastened to the ground (see below) at constant distances. By means of such an arrangements, one obtains the information of the values of vibration attenuation as a function of distance from the source. Directional properties of the transducers being, most frequently, piezoelectric accelerometers enable to measure the directional components in rectangular coordinate system. Using a method of fastening the sensors in groups of three, all three x , y , z components are measured in a defined point. The methodology of measurement performance proposed by these has defined the guidelines for the designed measuring set.

2 - MEASURING SET

Within the framework of project the set has been developed being a 8- and 16 channel digital recorder adapted to cooperate with the piezoelectric transducers of vibration [4]. The battery – operating power supply system enables to conduct site measurements for many hours. The set (block diagram shown in Fig. 1) is composed of an assembly of vibration transducers, analogue block of transmission receivers and digital block of data acquisition and storage. The signals from the transducers are transmitted in a two- wire current transmission. This ensures the possibility to install the transducers at a distance up to several hundred meters from the recorder. The digital block is controlled from a portable class IBM PC minicomputer provided with an A/D converter. A specialist software is an integral part of the recorder and enables the following:

- Selection of signal acquisition parameters.
- Acquisition of measurement data and storage of data.
- Automatic single and multi – channel detection of seismic tremors.

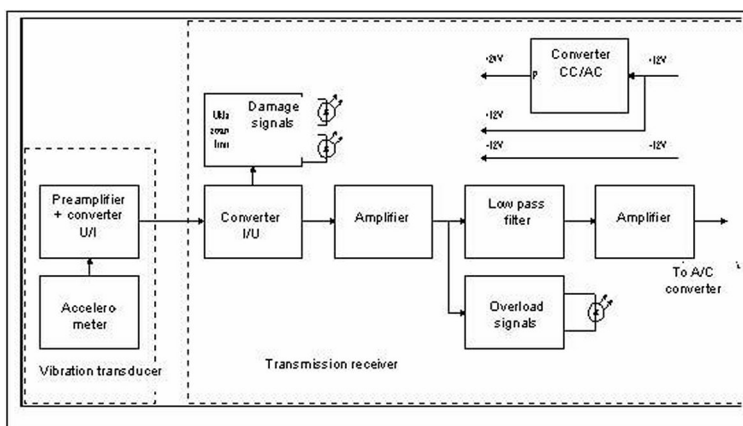


Figure 1: Block diagram for system measurements of traffic vibration.

The analogue part of the measuring set is composed of eight identical. Replaceable transmission receiving modules and the power supply module. Each of the modules transmission receivers constitutes a full analogue measuring line adapted to cooperate with the vibration transducers having preamplifiers operating in a current transmission system. With the aim of proper functioning of the system, considerable attention must be paid to selection of vibration transducers being the input circuits in the whole set. The following characteristics of it should be considered:

- mass and size of the transducers, which should not affect the parameters of the measured vibration,
- measuring range must include the predicted range of variation of the measured quantity,
- transfer band must include the frequency range predicted in measurements,
- sensitivity should high enough so that, with the measuring line used, it would be possible to obtain a reliable measurement of the measured value,
- sensor should be resistant to influence of the environment.

The vibration of the ground generated during movements of the structures are characterized by a relatively narrow range measured quantities, with such a condition that at a higher distance from the source, the values are already very small and, at the same time the frequency range in the band below 20 Hz is relatively narrow. The necessity to measure such small values needs making thorough selection of a vibration transducer. Therefore in a discussed set, the modified transducer PS – 1 designed and manufactured at CMI, has been used.

Table 1 presents the specification of basic parameters of the input circuit of the multi-channel system for measurements of traffic vibration.

3 - SOFTWARE

The measuring set is controlled through two computer programs: Program Win AC serves to record vibration and store the recorded data. It cooperates with the National Instruments DAQ-1200 A/D converter and Program Win View serves to visualize and manage the results of measurements of seismic and acoustical vibration. The program has the possibility to visualize measurement data stored in several formats. The possibilities in the field of measuring data management are different depending on the format of measurement data. The most privileged are the formats Win AC and WINTEXT as only they make accessible all options of the Win View program, connected with management of measurement results. These possibilities provide the user the full capability of managing the measurement result.

PARAMETER	DESCRIPTION
Number of channels	8 lub 16
Frequency band ($\pm 3\text{dB}$)	0,5Hz – 500Hz
Acceleration range	0,001 m/s ² – 1 m/s ²
Sensitivity of measuring channel (with vibration transducer)	5V/ms ⁻² – 25V/ms ⁻²
Transmission of signal from vibration transducer	current or voltage
Gain	Three-step gain control every 10 dB (0 dB – 10 dB – 20 dB)
Signalling of	Saturation short-circuit in cable line break in cable line
Power supply (including PC)	$\pm 12\text{V DC}$, ZA

Table 1.

4 - FASTENING OF TRANSDUCERS

Proper fastening of the transducers in the field measurements is one of the main difficulties in the whole process of preparation and execution of measurements. The existing conditions usually exclude the use of fastening recommended by the suppliers, by means of a threaded bolt with the known force of tightening. In the authors own practice a considerable dependence has been found of the measurement results on the method of fastening. The effect of the method of fastening has been assessed on the basis of an analysis of the frequency spectrum of a mechanical pulse excited by an impedance hammer falling on the ground [6].

5 - DATA BASES OF ROAD TRAFFIC VIBRATION

The operations comprising the storage of measurement data, various types of assessment and comparison with the standard, and connections with the maps of the measured area are accomplished by the database software installed, most often, in a stationary computer. The base was designed in the MS Access 7.0 program. The functions of the base can be easily adjusted to individual needs of the user. An original element of the base is the localization of the measurement data and geographical position of each of them by using a separate GPS module together with a suitable software. The results are presented on a digital map of the area, in our case, made with the use of Map Info Professional [4], [5].

A typical customer is interested in obtaining of a complex and clearly prepared information on the effects of mechanical vibration of the indicated area or evaluated structures. The program is composed of a number of options, the most important ones being: option **Wyniki badań** (measurement results) makes accessible the data base being a set of the expected information. The conception of the database ensures the possibility to place the maps of defined localities or smaller areas in which measurement points were localized. Indicating a defined measuring point and selecting the option **Karta pomiarowa** (measurement chart) leads to opening of the "folds" that give detailed information relating to location of the measuring point, such as:

- data defining the geographical position (three dimensions, after stationary correction of the correction base, including longitude, latitude and altitude in the Cartesian system as well as description of localization; detailed section from the map with the measurement points marked;
- data relating to recording, including: sampling frequency, number of channels and description of the measurement, in which characteristic data on measurement conditions etc. are contained.

The second fold **Ocena** (evaluation) gives a current state in the domain of effects of mechanical vibration emitted by transport means into the outer environment. This option is to enable to utilize the results both in valuating the condition of the environment and settling the questions relating to localization of new and modernized transport structures, in the scope realized by the customer.

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