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AUTOMATIC SYSTEM FOR MONITORING OF VIBRO-COMFORT OF VEHICLES

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ABSTRACT
Due to the desire for constant improvement of the quality of passenger traffic vibration comfort has become a very important parameter when designing vehicles. Occupants are constantly exposed to vibration caused by interaction between vehicle and road vibration and whose source is in the vehicle, such as motor cars. This work is focused on the measurement of vibration due to interaction with a moving vehicle on the road and the uneven impact of vibration on comfort.
The subject of this paper is the implementation of automatic vehicle tracking tamper-comfort implementing a method of measuring vibration comfort, while precisely locating the vehicle during the measurement, monitoring and measuring results with the help of tools GeoMedia Professional.
Keywords: vibration, vehicle, comfort, measuring

1. MEASURING OF VIBRO-COMFORT

Comfort is a term that has no strict definition and it is therefore very difficult to accurately measure and display the quantity. Some factors affecting the comfort is easy to express quantitatively, but most of is subjective character. Some of the factors that are believed to affect passenger comfort while driving are: seat vibration, vibration of the hand, foot vibration, acoustic vibration (noise), seat design, temperature, humidity, air pressure, distance between seats, and others. Research has shown that of all factors of comfort greatest impact on comfort levels of vibration i.e. the vibro-comfort is most important factor of comfort.
Aspirations to measure vibro-comfort so far were most based on measuring the sensitivity of the human body to vibrations of different frequencies. Generally accepted view is that it is vibro-comfort directly proportional to acceleration which acting on passengers while driving. This is why most of previous studies based on measuring the sensitivity of the human body to acceleration of different frequencies.

2. APSORBED POWER

To overcome the problem of tracking a lot of frequencies at the same time and to simplify tracking of results has been developed a method of absorbed power, which suggests that the vibro-comfort is proportional to amount vibration which human body absorb. This yields only one value commensurate with vibro-comfort. Absorbed power is calculated as the sum of mechanical forces on each contact with the passenger vehicle. Mechanical strength is calculated as the product of force and speed.
For measuring vibro-comfort need to measure only the value of acceleration. Required value of speed is obtained using integrals. To get the value of mechanical force by using values of the measured acceleration are defined weighting functions that depend on the mechanical properties of the human body.

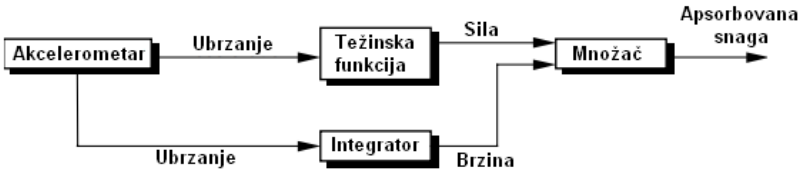

Figure 1. Method of measuring the absorbed power

The great advantage of this method compared to the previous is that as a result gets a single value that is largely proportional to vibro-comfort. The drawback is that there is disagreement between researchers about the proper shape of weighting function.
It was carried out an extensive testing by measuring the acceleration in real driving conditions. Collected data were analyzed with several types of weighting functions. During the test, travelers also rated comfort on a scale of most uncomfortable to the most comfortable. Test results showed that all the weighting functions used gave approximately the same results. All the results were approximate the actual values of comfort that was obtained by subjective assessment of passengers. The method of equivalent acceleration values without weighting function yielded results closest to actual value, and since this method is the easiest to implement was named as the best choice.

3. IMPLEMENTATION OF MEASUREMENT

The implemented system should provide the following functionality:

1. Automatic monitoring of vibro-comfort according to the method by the effective value of vehicle acceleration.
2. Determining the exact position where the test was realized.
3. Selecting data that are relevant in order to reduce quantity and increase the visibility of measurement results.
4. Save the measurement results in a format suitable for viewing on your computer.

Block diagram of the implemented system is shown in Figure 2.

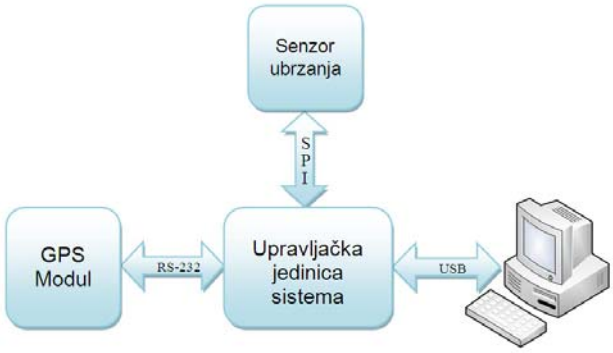

Figure 2. Block diagram of the implemented system.

The control unit of the system reads the values measured by the acceleration sensor, the coordinates of your current position and speed measurement devices, processes the obtained information and keeps them on a personal computer. Acceleration sensor consists of an analog accelerometer and microcontroller which digitizes analog sensor value. With the control unit is connected via the SPI bus. GPS module with a control unit communicates via RS-232 protocol. Communication takes place by the control unit sends AT commands, a GPS module responding to the commands. The measurement results are forwarded to a PC via USB connection.

4. WORKING PRINCIPLE OF THE REALIZED DEVICES

Sun SPOT as the central control unit is connected to the Telit GM862 GPS module via RS-232 serial interface which enables their communication. Sun SPOT using acceleration sensor located on the eDemo board constantly in equal time intervals measures the acceleration of vehicles on all three axes and analyzing the measured values. Sun SPOT is via USB cable connected to a personal computer on which is recorded and analyzed the measured values.

Implemented system is designed for automatic monitoring vibro-comfort by the method of effective value of acceleration. The system is designed to continuously measure and record the effective and maximum values of acceleration module at specified intervals. The effective value of acceleration "a_{RMS}" for a discrete system is calculated using the formula:

$$a_{RMS} = \sqrt{\frac{a_1^2 + a_2^2 + a_3^2 + \cdots + a_n^2}{n}} \tag{1}$$

The a_1 through a_n represents acceleration of the measured values, and n represents the number of samples in an interval measurement.

In the realized device is implemented a functions of detection of large quakes of vehicle caused by bumpy road on which the vehicle is moving, braking and sharp turning of vehicles, as well as the position and time at which these quakes occurred The system is designed to detect quakes that exceed a given value. Set point at each measuring module compares with the current measured acceleration. Module "A" currently measured accelerations are calculated from the formula:

$$A = \sqrt{X^2 + Y^2 + Z^2} \tag{2}$$

Where "X", "Y" and "Z" values of measured acceleration in each of the three axes.

If the value of the acceleration greater than the module set value, the current value of acceleration in all axes is recorded in the same time the request is sent to the GPS module to determine the current location, time, speed and direction of the vehicle. These values are formatted in a form suitable for review and also sent to the PC via a USB connection.

5. MEASUREMENT AND RESULTS OF MEASUREMENT

In order to begin measuring the Sun SPOT must be connected to a computer via USB cable, a computer must be running the NetBeans IDE with the loaded project, which running on the Sun SPOT. Selecting "Run Main Project" from the "Run" menu or press F6 are start the program runs in the Sun SPOT.

All messages that Sun SPOT sends your computer are displayed in the "Output" window NetBeans applications. A Sun SPOT measurement results formatted as a KML file format and sends them to your computer.

After each measurement period or due to detection of a large quake on the "Output" window will appear the results in KML format. Program continues to operate until the push button SW2 on the Sun SPOT. Then the Sun SPOT sends the final part KML file and shuts down the application. From the "Output" window we can then copy the entire contents and save the. KML file. So saved file can be opened in GeoMedia Professional application. In Figure 3 are shown the measurements performed in the town of Cacak. Red markers show measurements for which it was detected a quake of great intensity, and blue markers show measuring effective value of acceleration which is an indication of vibro-comfort. Next to each measurement is displayed and the number of measurements in order to know the path which the vehicle is moving.

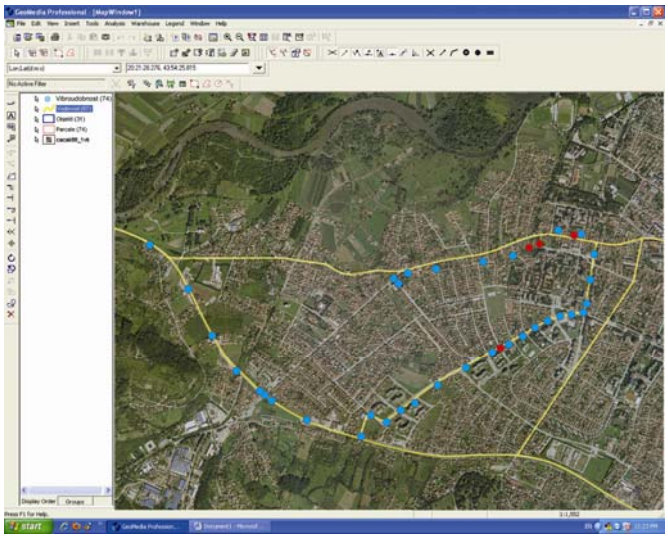

Figure 3. Preview of measurement results in GeoMedia Professional

For measuring the effective value of acceleration (blue markers), in the window for details of measurement can be read the following information, in order from top to bottom:

- Number of measurements
- The effective value of acceleration module for a given measurement values expressed in g-force
- Maximum value of acceleration in the measuring module timing values expressed in g-force
- The acceleration of the each axis values expressed in g-forces and percentage
- Speed and direction
- Latitude and Longitude position of measurement
- Date and time of measurement

6. CONCLUSION

This paper presents a system for automatic monitoring vibro-comfort of the vehicles. Using the implemented system was performed and laboratory measurements in real driving conditions, and thus confirmed its functionality. System during the measurement in real driving conditions continuously recorded effective value of accelerations that occur in the vehicle, which is a direct indicator of the level vibro-comfort. The system has detected and recorded the acceleration of high intensity, because their influence is also very important for determining the vibro-comfort. The measurement was done completely automatically, despite the very measurements to determine the vibro-comfort, are automatically recorded the locations where the measurements are made. The system has performed the analysis and selection of measurement and displays only those values that are relevant to the determination of vibro-comfort. The results are stored in KML file format, which allowed subsequent viewing of measurements on a computer using GeoMedia Professional software.

7. REFERENCES

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