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IMPLEMENTATION OF A GPS BASED PASS-BY MEASUREMENT SYSTEM

Edoardo Piana[*1] and Alberto Armani[2]

[1]Dipartimento di Ingegneria Meccanica, Università degli Studi di Brescia
via Branze 38, 25123 Brescia, Italy

[2]Spectra S.r.l
via Ferruccio Gilera 110, 20043 Arcore (Milano), Italy
piana@ing.unibs.it

Abstract

This paper describes an innovative pass-by system specifically developed to fulfil the Standard requirements. Such device runs on a highly flexible platform system, open to the various needs of the NVH field thanks to its design and software modularity.

Differently from other pass-by systems, it is based on a GPS receiver able to track both the vehicle position and its speed at a rate of twenty times per second. All the test parameters are fully selectable and the driver can interact directly with the application software installed on a small and light PC.

Since the system is GPS operating, there is no need to use any radar or light-barrier. The in-vehicle module acts as an interface for the driver and gathers several kinds of data: vehicle position and speed, engine temperature and engine RPM and throttle position. In the meantime, the Ground Station collects all the information about the acoustical parameters with an audio and video stream of the pass-by test. A bi-directional high transfer rate data connection via Wireless LAN is established between the in-vehicle unit and the ground base station, allowing real time data transfer of the main parameters. All the information can be displayed both on the pilot screen and, at the same time, on the base station PC. The acoustic measurements are performed by using a multi channel acquisition system. Each channel of the instrument can measure, in parallel and in real time, SLM values, FFT and 1/3 octave analysis. At the end of the test, the main acoustical data and the GPS quality parameters are shown to the driver, who can decide whether to accept the

measurement session or reject it. The driver can also decide to store the car paths together with the sound pressure level time history and the overall acoustic data of each session for further post processing.

INTRODUCTION

Noise emission control from moving vehicles has always been an important matter for manufacturers, not only to test the driver's comfort, but also from an environmental point of view.

Certification of noise emissions from passenger vehicles, motorcycles and light trucks is achieved by external sound pressure level measurements, according to those procedures defined in several international standards, such as ISO 362 [1], [2], [3] and ISO 13325 [4], that describe how to manage a noise assessment during the pass-by of vehicles. Most of such standards require the acquisition of sound pressure level together with engine rpm, vehicle speed and vehicle position.

The currently used procedure is based on pass-by measurements performed during fully open throttle acceleration. This test is useful to establish the maximum annoyance, but it is not representative of the actual urban traffic conditions.

Some new standard proposals suggest to perform tests based on a combination of constant speed and reference acceleration. Such a procedure allows to evaluate the perceived noise in urban environment more accurately. The new standards are conceived to take into account also other parameters, such as the type of vehicle and the power of the engine. The new standard is expected to be in force by 2008. Thus automotive manufacturers will soon have to replace the old systems with the new ones, which should be able to meet the regulations under development.

Recent improvements in positioning systems allow reliable real time measurements of the mentioned parameters with an adequate grade of accuracy. Moreover, WLAN improvements permit data exchanges between the ground measurement system and the driver over large areas, thus introducing new kind of tests suitable for research and development aims. Since the system is GPS operating, there is no need to use any radar or light-barrier. For the same reason the number of cable connections is reduced as well.

STANDARD REQUIREMENTS

Certification of noise emission from moving vehicles is achieved by measuring sound emission according to the procedures described in ISO 362 (1998). This standard is based on pass-by tests where overall noise levels are measured during fully open throttle acceleration in 2nd or 3rd gear. A generic measurement set up for pass-by noise is shown in Figure 1. The vehicle comes close to the test zone at a constant speed. When it reaches the line symbolized by AA' (gate 1), the driver opens the throttle wide and accelerates until the line BB' is reached. Maximum A-weighted overall sound pressure levels are measured on both sides of the track by microphones and they are averaged over a number of passages.

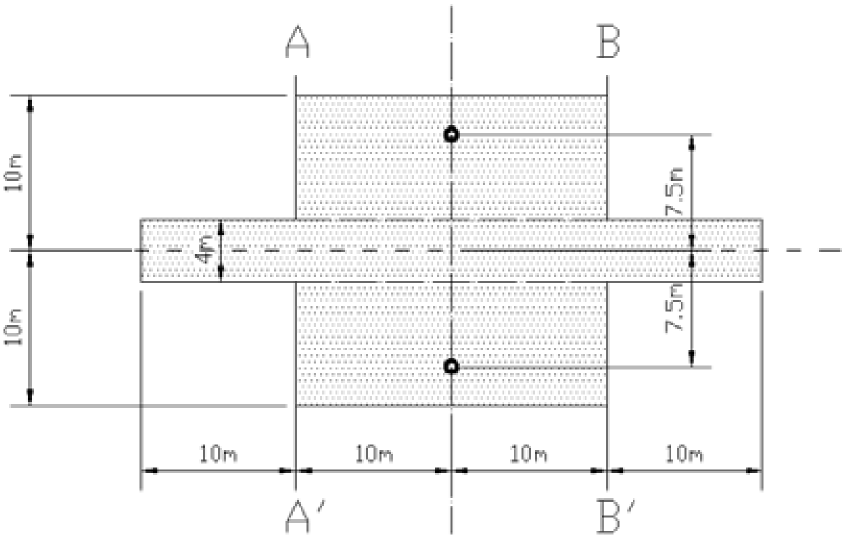

Figure 1: Measurement set-up according to ISO 362.

In recent years several concerns have overcome about the evaluation of tests carried out using the standards constriction, mostly because high acceleration in low gears is indeed not representative of actual driving practices. Besides, the most significant perceived annoyance levels, do not correspond to those coming from acceleration.

Finally, several innovative indicators will be introduced by the new standard:

- Power-to-mass ratio
- Selection of the test gear
- Constant speed tests
- More severe test tolerances

The increased complexity of the test procedures will result in a series of new challenges for vehicles manufacturers. To be able to meet these challenges effectively it is peremptory to set up adequate measurement systems.

SYSTEM LAYOUT

The above pass-by system consists of four main sections. Three of them are connected to the vehicle:

- GPS and WLAN antennae (placed off board);
- GPS receiver, WLAN and power supply module;
- lightweight notebook PC and application software.

Another important item is the ground base station with acoustic acquisition system. It is fixed on the ground, manages the acoustic acquisition and gathers weather conditions data. Figure 2 shows a generic layout of the pass-by system.

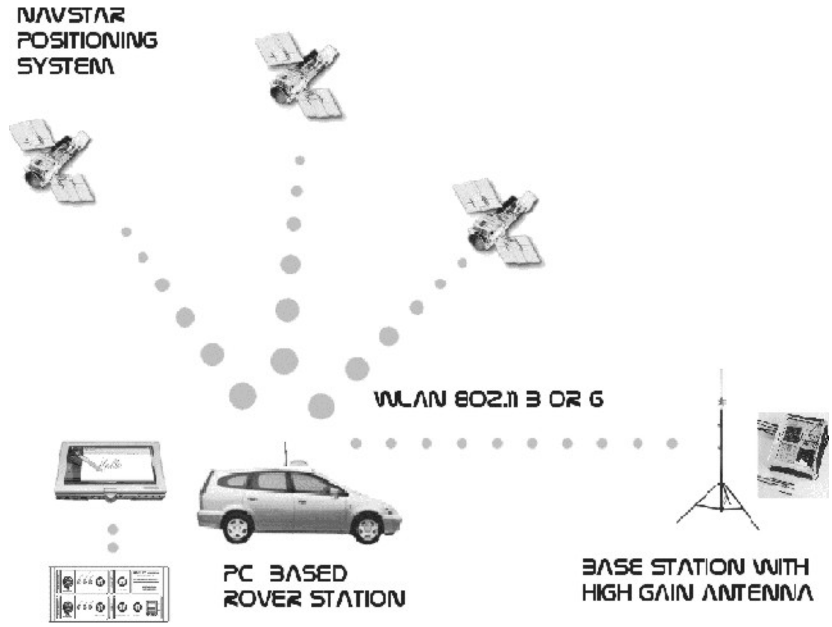

Figure 2 – Generic layout of the pass-by system.

The in-vehicle module acts as an interface for the driver and gathers several kinds of data: vehicle position and speed, engine temperature, engine RPM and throttle position. In the meantime, the ground station collects all the information about the acoustical parameters with audio and video stream of the pass-by test, and environmental data as well.

Rover Unit

The Rover Unit is based on an external unit for data transmission and an inside car unit serving as an interface for the driver. The external unit collects the GPS and the WLAN antennae. Figure 3 illustrates the external unit mounted on a car.

The driver can interact with the pass-by system through the PC touch screen. A bi-directional high transfer rate data connection via Wireless LAN is established between the in-vehicle unit and the ground base station, allowing real time data transfer of the following parameters: vehicle position, vehicle speed, engine RPM sound pressure level, overall acoustic data, FFT spectra, 1/3 octave spectra and engine temperature. All the test parameters are fully selectable and the driver can interact directly with the application software installed on one of the smallest and lightest PC now available on the market. Figure 4 shows the arrangement of the system inside a vehicle.

Figure 3 – External unit of the pass-by system.

During the tests the driver has to pay attention only to the road, since the system is self-operating and will warn him about the close proximity of a gate, the rpm range and the speed limit by sending forth acoustic signals.

Figure 4 – Inside car arrangement of the pass-by system.

At the end of the test, the main acoustical data and the GPS quality parameters are shown on the PC screen (Figure 5). Through a quick analysis of the information, the driver can choose whether to accept the measurement session or reject it. The driver can also decide to store the car paths together with the time history and the overall acoustic data of each session for further post processing.

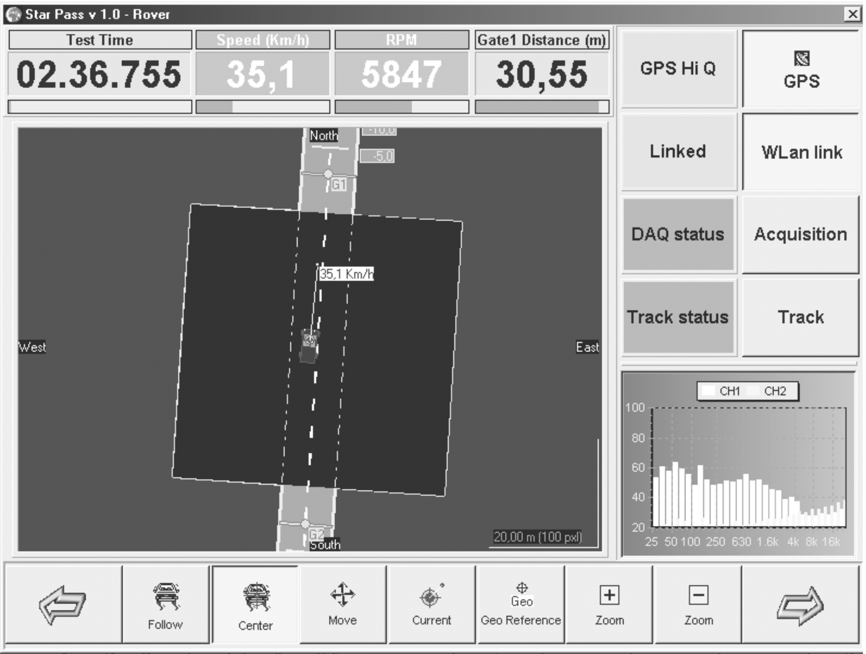

Figure 5 – Main acoustical data parameters during a measurement session

Several profiles for different users or measurement types can be stored, thus allowing a fast setting up of the system.

Base Station Unit

The Base Station Unit operates as an acoustic data collection system and weather station module. All the information gathered by the base station can be displayed both on the pilot screen and, at the same time, on the base station monitor.

The base station consists of: a WLAN access point, a high-gain antenna, an acoustic acquisition system, a personal computer and a weather station.

The acoustic measurements are performed by using a multi-analysis system (2/4/8 channels) according to IEC651, IEC804 type 1, IEC61672 Class 1, IEC1260.

Each channel of the instrument can measure, separately and in real-time, SLM values, FFT, 1/3 octave analysis together with *.wav* recording, separately and in real time. The analyser can use a wide range of transducers available on the market, like ICP and TEDS.

Once the test has been carried out, the main acoustic parameters are displayed by the application software both on the driver’s terminal and on the base station PC. Figure 6 shows an example of the outputs obtained after that a pass-by measurement has been performed.

Figure 6 – Acquired speed and acoustical data after a measurement session.

EXPERIMENTAL RESULTS

The pass-by system described in this paper is currently adopted by several institutes as a useful assessment, research and investigation tool. Acoustical data obtained by such system have been verified by comparing them to the ones measured by other pass-by systems based on optical barriers and laser speedometers. It has been found that results obtained are substantially the same in both cases. From a metrological point of view, a very little speed difference has been measured between the two systems, while the positioning precision is about 5 - 10 cm if high-quality GPS signals are used.

Other tests have been carried out by placing the GPS antenna in close proximity of another high quality, differentially corrected system antenna, and correlating the two data series. In this case too, the results show very good agreement for both position and speed data. In order to avoid the use of the system in low-quality mode, the application software implements a quality-check system able to indicate to the driver and to the ground staff if the measurement carried out can be considered sufficiently reliable. Figure 7 shows the application software screenshot for the quality section.

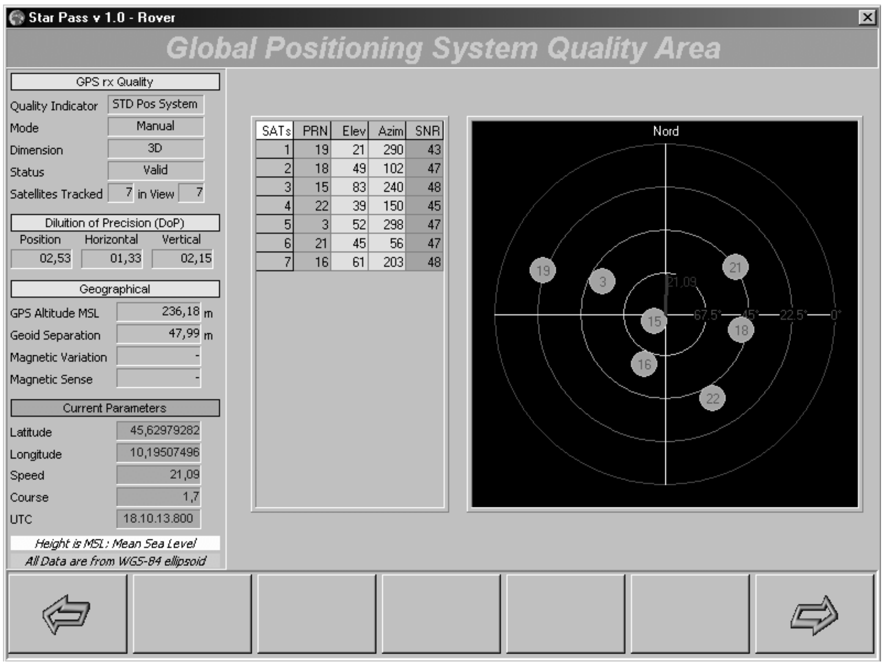

Figure 7 – Application software quality area

SUMMARY

In a different way from other pass-by systems, the application described in this article make use of the Global Positioning System to establish both location and speed of the vehicle under test. This feature will simplify the application of the new standard that will change the pass-by measurement procedure. Moreover, WLAN connection of the base station (ground) to the in-car unit enables the driver to control directly the parameters and the results as well, thus making superfluous the assistance of a ground staff.

REFERENCES

[1] "Acoustics -- Measurement of noise emitted by accelerating road vehicles - Engineering method", ISO 362 (1998).

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