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Development of The Road Analysis System to Provide the Fuel Efficiency Awareness in the Vehicles

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Abstract: Damaged roads, speed bumps and potholes are quite annoying for drivers. Bad roads that damage the suspension system can cause accidents as well as damage to cars. In this study acceleration-deceleration parameters of vehicles are measured by using mems based accelerometer depending on the road condition. In this way, the driving characteristics of the driver can be observed. After determining a rating system based on classes of vehicle acceleration, drivers can be compared their driving characteristics with this system. The vehicle drives can be encouraged to use with low acceleration. When specified acceleration level is exceeded, visual and audible warning system is activated and the driver is alerted. The drivers are encouraged to use the vehicle with low-level acceleration. It means leads to a reduced fuel consumption, reduced exhaust emissions and longer life of the vehicle. For this aim, 7480 measured data (2451for shock absorber test, 5029 for determining the barriers on the road) were analyzed. The results were plotted and proved to be quite similar to each other. So, the developed economic system could be an alternative to the test methods used in the industry.

Keywords: Accelerometer, microprocessor, road analysis, shock absorber, fuel efficiency

1. Introduction

During the acceleration and deceleration of the vehicle, inertia forces are generated in the vehicle in the reverse direction. The force encountered during the movement of the vehicle is called the "Acceleration Resistance", since it is opposite in direction to the acceleration and consists of the inertia forces of the masses in linear motion and the rotational inertia forces of the wheels (Cetinkaya, 2010). Braking, accelerating, and changing the direction of a vehicle creates momentum on the vehicle (Bayrakçeken et al., 2009). For this reason, acceleration and deceleration of the drivers cause acceleration resistance on the vehicle. There are systems that provide audible stimulation to drivers according to acceleration resistance, allowing them to drive more controlled (Sümbül, 2013; Pothole, 2017). But these systems are not cheap and do not have widespread use.

2. Material and Method

The data recording and transfer system consists of 3 parts; microcontroller data acquisition unit, data transfer unit and software. The system includes Arduino Mega microcontroller, 2x24 character LCD display, ADXL345 acceleration sensor, and SD memory and data transfer circuit. All of the power is fed from a 12V battery source. In the system, the acceleration changes in the X, Y and Z axes of the vehicle are measured in real time with the accelerometer and recorded on the SD card during driving. The measurements were carried out at varying speeds (20km / h, 30km / h) on a track that 120m long with 3 barriers. Drive speed and road obstacle conditions are analyzed in 3-axis in the Cartesian coordinate system.

2.1. Test Racecourse

The measurements were carried out in front of Yesilyurt D.C. Vocational School, Ondokuz Mayis University in Samsun, Turkey. The test racecourse consists of a road with a total length of 120m with 3 barriers. The distance between the barriers is

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measured as 25m and 28m. The barrier height is about 10 cm. Figure 1 shows a space view of the area where the measurements are performed.

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Figure 1. The view of the area where the measurements are performed.

2.2. Acceleration Sensor

MEMS semiconductor technology combines micromechanical structures and electrical circuits on a single silicon chip. With this technology, MEMS based accelerometers sense acceleration on one, two or even three axes, with analog or digital outputs. The ADXL345 is also a MEMS based 3-axis accelerometer with digital output. It is manufactured by Analog Devices Inc. It features a selectable ±2-g, ±4-g, ±8-g or ±16-g measurement range (selected the ±2g setup in this study); resolution of up to 13 bits; fixed 4-mg/ least significant bit (LSB) sensitivity; a tiny 3-mm × 5-mm × 1-mm package; ultralow power consumption (25µA to 130µA); standard 2-wire Inter-Integrated Circuit (I2C) and Serial Peripheral Interface (SPI) serial digital interfacing; and 32-level first in first out (FIFO) storage (Ning, 2009). MEMS accelerometers that are used from military areas to health care industry have been explained in (Goetenberg at al, 2007; Sümbül at al, 2016). Hence, this combination of features makes the ADXL345 an appropriate accelerometer to observing the movements of diaphragm for our study. Figure 2 shows the accelerometer used in the experiments

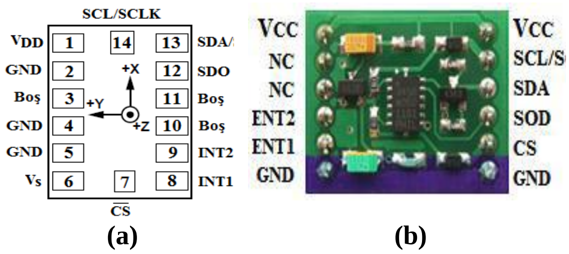


Figure 2. ADXL345 accelerometer, a) pin structure, b) circuit structure (Analog Devices, 2017).

2.3. Measurement Device

At the control circuit, an acceleration sensor which has the ability to define position by using 3-axis cartesian coordinate systems is used to measurement of accelerations from the car. The accelerations data measured by the sensor were recorded on the SD card (32 GB). Figure 3 shows a block diagram of the designed and realized system.

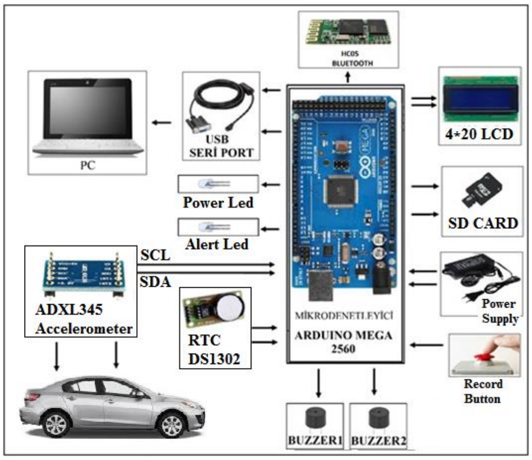


Figure 3. The block diagram of designed and realized system.

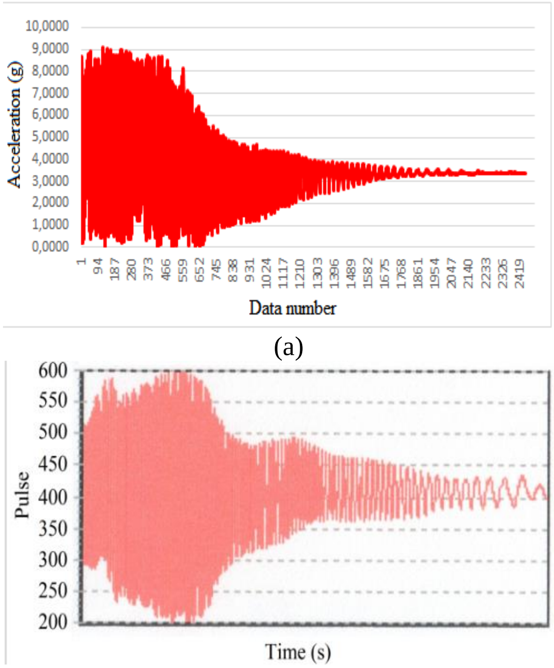
Sampling frequency of designed and realized system is 20Hz. Each 32-bits of float received data are composed of x, y and z data. Thereby, the amounts of data transferred are 20 x 3 x 32 = 1920 bits / sec and it is suitable for a wireless transmission.

The circuit of the system was composed of Arduino Mega (preferred because of the need for the number of peripheral ports) microcontroller (licensed with Creative Commons Attribution Share-Alike 2.5), 4x20 character LCD display, accelerometer sensor, SD memory component, RTC (real time clock, produced by the Dallas company,) and a button (for recording). The required power for the entire circuit has been obtained from a circuit containing a 12V battery. Arduino board is being programmed with the Arduino Software (IDE). V.1.6.4 software was used to program the Arduino microcontroller. The accelerometer was extended via a cable (usb type of cable) during the tests.

The acceleration sensor was positioned on the right front suspension system of the vehicle, perpendicular to the Z-axis. So Z axis information was used in the measurements.

3. Results

Firstly, in order to examine and compare the performance of the developed analysis system, the vehicle's shock absorber test was performed. During the test, the real test device used in the industry and the developed system were connected together to a car and the shock absorber test was carried out simultaneously (At SERP car vehicle test center, Samsun). Measured 2451 z-axis data were analyzed. The results were plotted and proved to be quite similar to each other. Figure 4 shows simultaneously shock absorber test results. So, the developed economic system could be an alternative to the test methods used in the industry.



(a)

(b)

Figure 4. The shock absorber test results, a) developed device, (b) industrial test device.

Secondly, 5029 Z-axis data were analyzed with the aim of determining the barriers on the road. The maximum acceleration that occurs when passing through 3 points on the road (look at figure1) belongs to where the barriers are located. Figure 5 shows the accelerating response of the on-road disturbance to the vehicle in terms of vehicle speed (20Kmh, 30Kmh).

The three vertical piles shown in Figure 5, represents the presence of the barrier and the situation that occurs when the vehicle crosses the barrier. As can be seen, the number of barriers on the road has been achieved successfully and clearly. Similarly, pits on the road can be found easily with this device. While the column length represents the height of the barrier on the road, column width represents the length of the barrier on the road. Figure 5 also gives information about the speed of the vehicle and the vehicle's barrier speed.

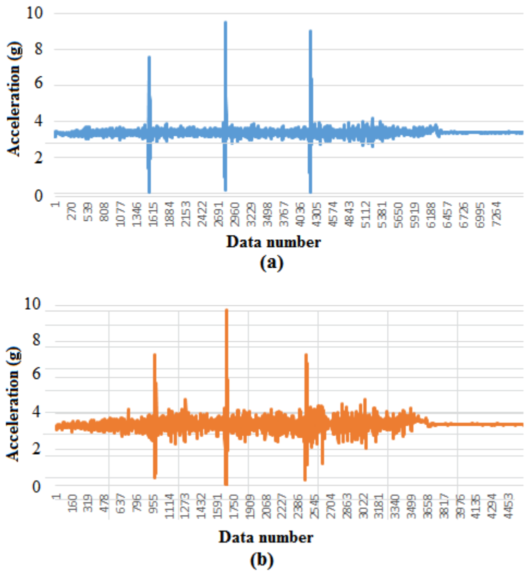


Figure 5. Accelerating response of the on-road disturbance to the vehicle in terms of vehicle speed, **(a)** 20Kmh, **(b)** 30Kmh.

4. Discussion and Conclusions

Thanks to the designed system, acceleration control can be provided in the cars. The drivers are alerted by the warning system to reduce their acceleration and thus do not make unnecessary acceleration or deceleration depending on the road conditions during driving. Thus, unnecessary fuel consumption can be avoided, which can be caused either by driver use or by roadside faults. The design can be controlled with accelerometer and software to be added to the Electronic Control Unit (ECU) in the newly manufactured vehicles. Moreover, once the average acceleration value reaches the limit value, the ECU can reduce the acceleration by controlling the fuel system through the software to be developed. With this system, an acceleration rating system standard to be prepared according to vehicle class will be established. According to this standard, the comfort of public transportation is increased by restricting acceleration to public transport vehicles. Private fleet companies can improve their fuel consumption by limiting the driver's use of accelerated vehicles. This will provide a safer traffic environment. Automotive factories can optionally offer average acceleration monitoring systems to customers to drive their vehicles with minimal fuel consumption in urban traffic.

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