Bulletin of the *Transilvania* University of Braşov • Vol. 10 (59) No. 2 - 2017
Series I: Engineering Sciences

# IOT SMART SENSOR FOR DROP TESTS ON INFLATING PRODUCTS

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***Abstract:*** *Testing products in for industry became a standard in our age. Products used in real life must be tested especially when life or safety could be in danger in order to demonstrate the safety of the products and for consider all the possible dangerous situations. When physical activities are involved all these issues become more important. In this paper is described a smart sensor that can provide data for a dropping test, simulate in very similar real life situation, a dropping human body on an inflatable product. This test was conducted in AIRQUEE factory, a top company in world of inflatable products, for testing an innovative product, with respect all real life scenario.*

***Key words:*** *Internet of Things, Smart sensors, drop test.*

## 1. Introduction

This paper describes developing the IoT Smart testing system, and testing the product of Airquee SRL on drop test. All test were carried out under strict observation of safety and were recorded with camera. The inflatable product were provided by Airquee, were inflated at their factory on a rigid concrete floor, and all the set-up reflect real working condition for the product, using recommended equipment for inflating and securing the product.

Dropping weight was released on 2 points (A and B) for testing different target points on product, reflecting the possibilities in real life conditions. It consist in rigid steel cylindrical blocks of 200 mm in diameter and 10 or 15 kg, stacked up until tested weight. On top was rigidly fixed measurement equipment. During tests, depending on weight, after impact, weight could touch on size, which will produce accelerations on X, Y, axes and this will led to bigger correlated data.

Dropping height was measured with a ruler and reflect working conditions at 3.2 m (maximum possible is at 5 m but is not possible to use in real conditions).

The deceleration was measured using an automated system developed by authors, based on IoT and providing smart capabilities in order to maintain real life situation. The automated system mentioned before was also used attached to a testing professional stunt person. Measurements are based on a calibrated tri-axial accelerometer. The Z-axis deceleration was considered correlated with X and Y data. During tests, more than 5000 samples were taken (approximately at every 1 ms). All the signals were smoothed using Kalman filter and also FFTD filter.

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## 2. Automated Testing System

Nowadays internet of things is one of the most used technology in order to give “intelligence” to electronics systems. We are witnesses on how computers have transformed work and play, transportation and medicine, entertainment and sports. More than that everything is now connected to internet. And of course this is not only for fun. In our automated system, this concept will provide real time data from a smart sensor in order to conduct a test very similar with real life situations. For sure, there are other possibilities to achieve that, but this technology become more and more popular and microchips manufacturers provide more and more (and also cheaper and cheaper) new products. Based on these considerations, choosing internet of things for transferring pretty large data from sensors to computers is a natural choice, even in the systems that are not open to internet and use only intranet [9].

State of the art is based on systems that records acceleration during tests and after that all data sets are processed. Our system could provide real time date due to IoT technology. In present, tests are made in designed laboratories with specific equipment. The present accepted standards in inflatable air product limits deceleration of user at 20 g without carrying the height, weight or other relevant properties. Our test will take care of any possibilities that could occurs in use of the system, possibilities that are established together with manufacturer (European standards EN 71-1:2005) [6].

The core for our automated systems is based on STM32 IoT Discovery Board, developed by STMicroelectronics. This company has a goal in augment real life which is very similar with our test demands, consisting not only in feeling deceleration of human dropping body but also in scientific measuring these decelerations [5]. The STM32 IoT Discovery Board use a STM32L475 MCU (80 MHz/100 DMIPS, ARM Cortex M4) and is connected to a main computer on a Wi-Fi network, with respect to internet of things technology, in a configuration like in Figure 1.

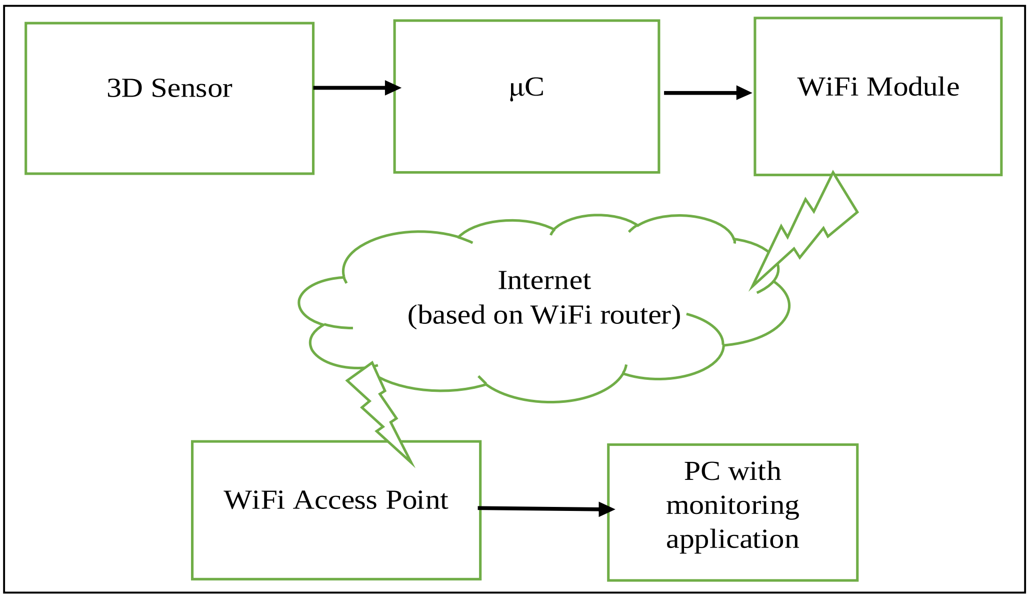


Fig. 1. *The automated system*

During the measurement all the communications are stopped for precision. After measuring period, all the data stored in RAM were wireless transmitted on a server running Linux-Debian. These compact systems assures maximum of precisions because of possibility to be close to mass dropping system. Immediately, all data stored in RAM are sent to server. On server a bot routine create a file with time information of captured data. These files are stored, filtered and processed and the user could see the charts with maximum filtered and raw data. This possibility adds value to real life test because you can adjust the test conditions in order to obtain data from very different real life situations [1, 3, 4].

## 3. Setup the Test

The inflatable product were provided by Airquee, were inflated at their factory on a rigid concrete floor, and all the set-up reflect real working condition for the product, using recommended equipment for inflating and securing the product.

Dropping weight was released on 2 points (A and B) for testing different target points on product, reflecting the possibilities in real life conditions. It consists in rigid steel cylindrical blocks of 200mm in diameter and 10 or 15 kg, stacked up until tested weight. On top was rigidly fixed measurement equipment [4, 7].

During tests, depending on weight, after impact, weight could touch on size, which will produce accelerations on X, Y, axes and this will led to bigger correlated data.

Dropping height was measured with a ruler and reflect working conditions at 3.2 m (maximum possible is at 5 m but is not possible to use in real conditions). Figures 2 and 3 reflect the main view of products, dropping sample and height measurement rule.

The deceleration was measured using an automated system based on a calibrated tri-axial accelerometer. The Z-axis deceleration was considered correlated with X and Y data. During tests, more than 5000 samples were taken (approximately at every 1 ms). All the signals were smoothed using Kalman filter and also FFTD filter.

The deceleration generated during falling and impact was measured by the accelerometer attached on top of the dropping mass. On every chart, maximum point (unfiltered and filtered) was identified and mentioned.

Also a WiFi network was created in testing room in order to connect all the things to the internet of things concept. The network shared by the smart sensor (connected to STM32 IoT Discovery Board), STM32 IoT Discovery Board, and the laptop running Linux Debian server is not connected to internet but this particularity does not affect the concept. Of course that the Linux Debian server could be everywhere in the internet and connection with STM32 IoT Discovery Board, could be made via VPN using safety of tunnelling concept. We preferred this setup because of the necessity of participating directly to experiment and to adjust the setup after every measurement [2, 8].

The router and access point were combined in a single powerful equipment in order to increase the compactness of the system. We used an equipment capable of 300 Mbs on 2.4 Ghz WiFi network. The setup can be extended in any moment, simply by configuring the network, the internet connection and of course the computers, with respect to data security and data transfer capacity. All equipment used in our setup can be rearranged in order to function on internet not only in intranet because all the setup respect internet of things specifications. Also, internet connection can be realized on fixed or wireless provider.


Fig. 2. *General view*

Fig. 3. *Dropping sample and high measurement*

## 4. Experimental Results

During test, the results are presented in Table 1. It can be seen that the equipment is safe for human use including children and because of the maximum weight used in test the maximum weight of the persons that use the equipment is limited at 130 kg.

*Maximum deceleration for different conditions* Table 1

| Test no. | Impact point | Weight [kg] | Height [m] | Maximum deceleration [g] |
|---|---|---|---|---|
| 1 | A | 130 | 2.5 | 4.55 |
| 2 | **A** | **130** | **3.2** | **6.43** |
| 3 | A | 130 | 4 | 8.55 |
| 4 | **A** | **130** | **5** | **9.71** |
| 5 | A1 | 85 | 2.5 | 5.11 |
| 6 | A1 | 85 | 3.2 | 5.49 |
| 7 | A1 | 85 | 4 | 5.74 |
| 8 | A1 | 85 | 5 | 7.83 |
| 9 | B | 130 | 2.5 | 3.91 |
| 10 | B | 130 | 3.2 | 4.27 |
| 11 | B | 130 | 4 | 6.50 |
| 12 | B | 130 | 5 | 8.41 |
| 13 | B1 | 85 | 2.5 | 4.77 |
| 14 | **B1** | **85** | **3.2** | **5.75** |
| 15 | B1 | 85 | 4 | 7.31 |
| 16 | **B1** | **85** | **5** | **8.67** |

In the next Figures (Figures 4 and 5) are presented 3 different relevant tests with conditions of test and maximum decelerations.

Finally, the equipment passes all tests with the results:

Drop test 1:
Weight: 130 kg, Height 3.2 m: Maximum deceleration –6.43 g

Drop test 2:
Weight: 130 kg, Height 5 m: Maximum deceleration –9.71 g

Drop test 3:
Weight: 85 kg, Height 3.2 m: Maximum deceleration –5.75 g

Drop test 4:
Weight: 85 kg, Height 5 m: Maximum deceleration –8.67 g

Overall results: PASS at drop height of 3.2 m and 5 m.

These results also validate the use of the automated system in testing inflatable products for dropping and impact.

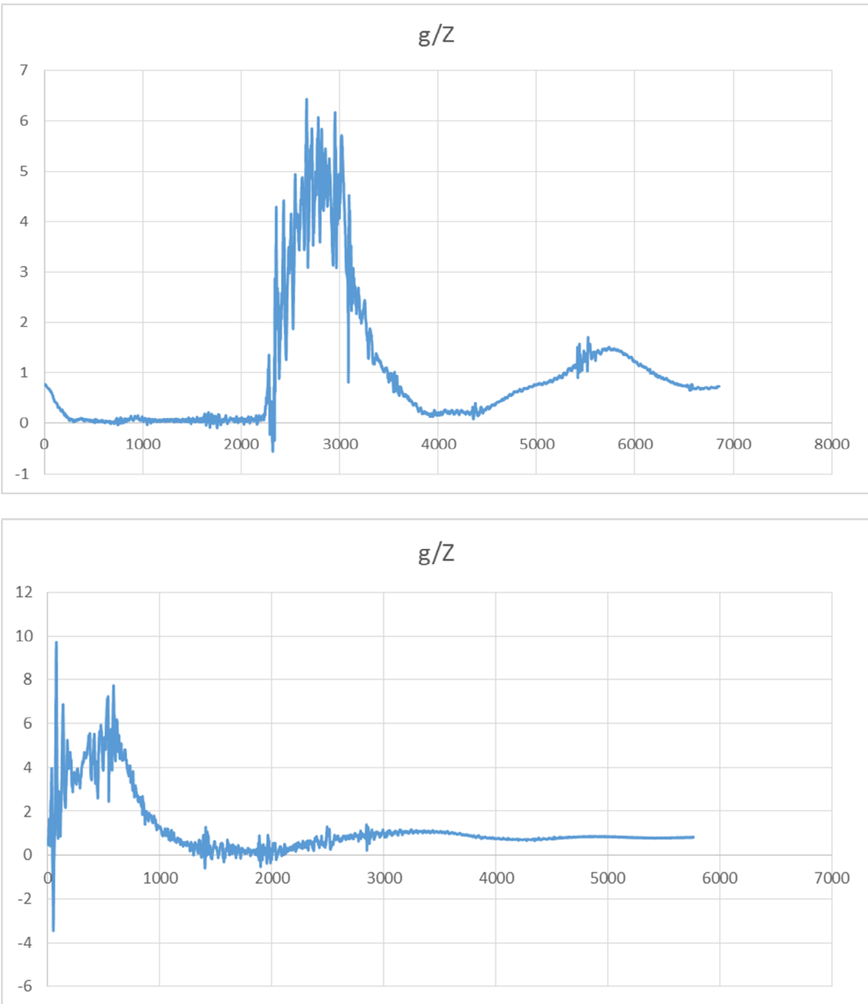


Fig. 4. *Dropping test 1,2; Weight: 130 kg, Height 3.2/5 m: Maximum deceleration –9.71 g*

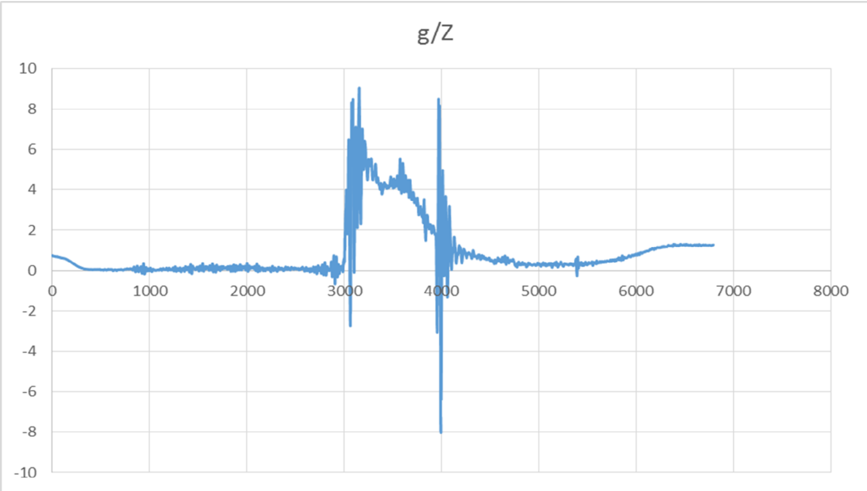


Fig. 5. *Dropping test 3; Weight: 85 kg, Height 5 m: Maximum deceleration –8.67 g*

## 4. Conclusions

This testing method is very efficient because of the rapidity of the results, and also because of the versatility of data acquisitions during the test. Because of the internet capabilities, all the data are online available during tests and also the product validation.

## Acknowledgements

We hereby acknowledge the structural founds project PRO-DD (POS-CCE, 0.2.2.1., ID 123, SMIS 2637, ctr. No. 11/2009) for providing the infrastructure used in this work. The authors thank the Airquee SRL management and collective, for support in test.

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