DEVELOPMENT OF DIY RAIN GAUGE OF REASONABLE COST

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Summary: *Data regarding the quantity and the intensity of rainfall is needed for the purposes of the hydrotechnical practice. The Republic Hydrometeorological Service of Serbia is the organization responsible for measurement and collecting of rainfall data. Unfortunately, this data is sometimes not available at desired time frames or in required locations, therefore it is necessary to temporarily use a self-maid or commercial rain gauge. There are an inexpensive tipping bucket rain gauges on the market but with questionable measuring accuracy. In this paper the self-constructed cheap weighing rain gauge has been presented. Its characteristics and specification are analyzed, as well as its areas of use in the hydrotechnical practice. Finally, the comparison of measuring results obtained using this rain gauge and professional, more expensive devices is given.*

Keywords: *Rain gauge, hydrometeorology, measurement, precipitation*

1. INTRODUCTION

For the purpose of hydrotechnical practice, data regarding the quantity and intensity of rainfall is needed. However, this data is sometimes not available at desired time frames or in required locations, therefore there is a need to temporarily use own rain gauge at a certain location. Acquiring an inexpensive tipping bucket rain gauge on the market is possible, although with questionable measuring accuracy. Having that in mind, a cheap weighing type rain gauge has been constructed, with the use of Arduino [1] platform for force measurement. Several rain gauges for intensity and rainfall quantity have been installed at the meteorological station of the Faculty of Civil Engineering, University of Belgrade, to compare with the developed "Arduino based rain gauge". Construction of the rain gauge as well as the measurement results are presented in the following text.

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2. CONSTRUCTION DESCRIPTION

Rain gauge (Figure 1) consists of a funnel, container and support structure with a load cell (Figure 2), which is connected to the acquisition module through a set of cables. The container doesn't have an automatic discharge system and its volume has been chosen in a way that annual rainfall amount can fit inside of it. The funnel surface is usually chosen to be 200 cm^2, however, in this case, to increase the volume of collected water, the surface of the Arduino based rain gauge funnel is 310,24 cm^2.

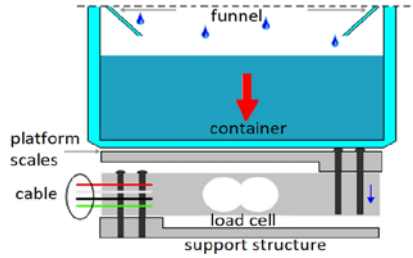

Figure 1. Rain gauge construction

The "heart" of the weighing type rain gauge is the load cell (Figure 2). The reference rain gauge OTT PLUVIO2 [2] has load cells from the well-known manufacturer HBM Z6 [7] 50kg in C6 class (Figure 2, top right), that guarantees a minimal resolution of 50000/6000=8,3 gram. Next to the reference rain gauge, the rain gauge with a "medium range" load cell has been constructed by using the HBM AED [8] measuring module and HBM SP4M [6] 10 kg load cell in C6 class (Figure 2, bottom left), at 1,7 gram resolution.
The cheap, Arduino based rain gauge, presented in this paper, uses a "no name" manufacturer load cell priced as just few euros, 5kg range with D1 class and 5000/1000 = 5 gram resolution. (Figure 2, bottom right). All aforementioned load cells work on the principle of strain gauge connected in a Wheatstone bridge, therefore these transduces are rated 350 Ohms for the HBM load cells and 1000 Ohm for the D1 class load cell.

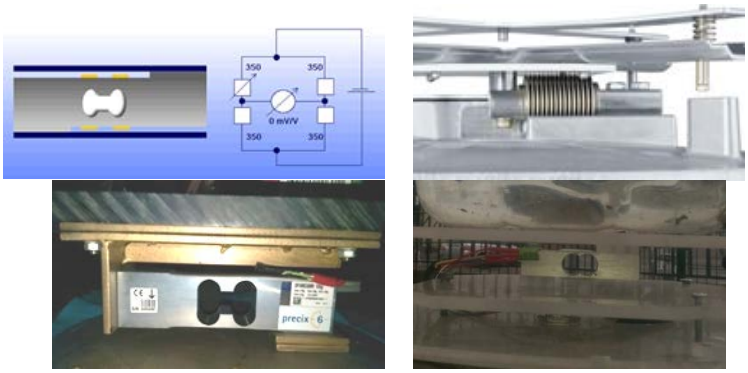

Figure 2. Rain gauge load cell – principle (top left), OTT pluvio2 [2] (top right), HBM AED [8] with SP4M [6] (bottom left), Arduino UNO [1] hx711 [2] with "noname" 5kg (bottom right)

The “brain” of the Arduino based rain gauge is Arduino UNO [1] (Figure 3, top right) with a 24 bit AD converter HX711 [2] (Figure 3, top centre) for reading data from the D1 load cell (Figure 3, top left). To collect data from the “brain”, the data logger shield (Figure 3, bottom) has been added. It has a RTC (real time clock) for real time readings and a SD card for data storage. Total price of a setup like this one is just under 50 euros!

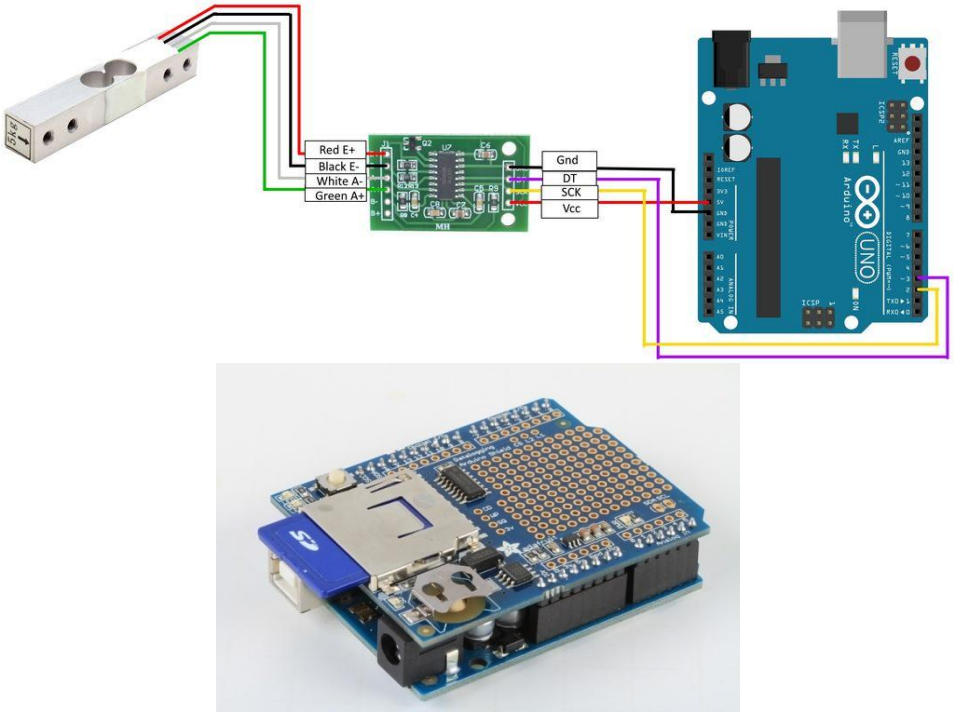

Figure 3. Rain gauge acquisition module

Calibration of the Arduino based rain gauge (Figure 4) has been done with the standard weights within the load cell’s measuring range.

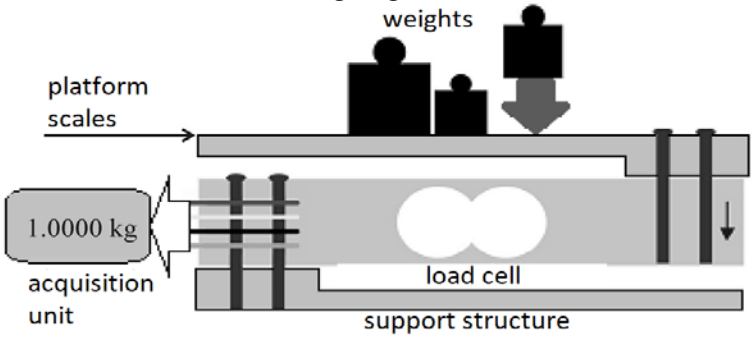

Figure 4. Rain gauge calibration

After conducting calibration, the rain gauge was mounted in the meteorological area of the Faculty of Civil Engineering, University of Belgrade, (Figure 5, right), nearby to other rain gauges. Arduino based rain gauge (Figure 5, left) measures the mass of collected water (in grams) every second. Further post-processing separates the periods with evaporation (no rainfall period), and removes the noise produced by water droplets and wind. Post-processing of the measured water mass into total rainfall and intensity is done by averaging values in a minute interval and by removing readings below 0.005mm/min.

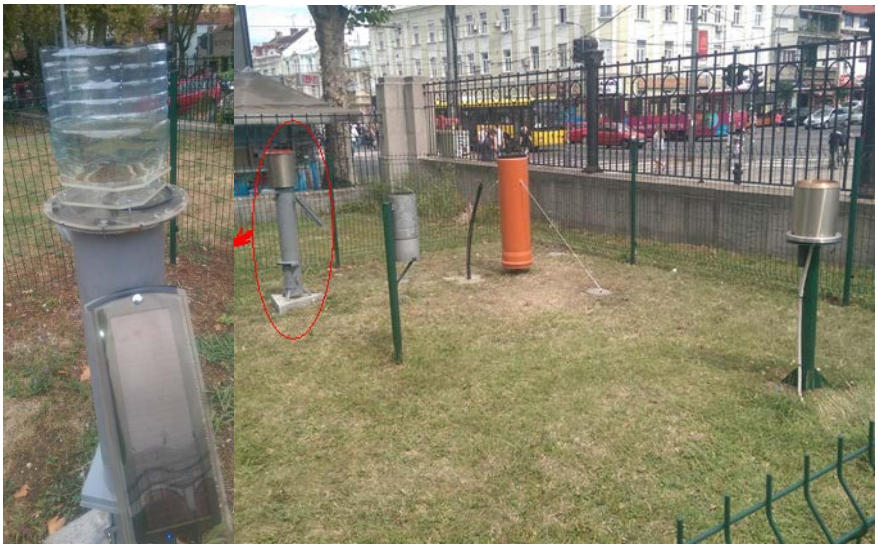

Figure 5. Meteorological area of the Belgrade Faculty of Civil Engineering (right) with Arduino based rain gauge (left)

Arduino based rain gauge has been tested since June 2015. During this time period, there were small temporary losses of data due to the use of batteries that must be charged once a month, so in the next phase bigger solar panel should be used or alternatively, the data sampling rate should be reduced to a minute maximizing the battery life.

3. RESULTS OF THE MEASUREMENTS

In order to compare the data, high intensity rainfall (Figure 6, top, about 1 mm/min, June 2015) and low intensity rainfall (Figure 6, bottom, about 0.1 mm/min, October 2017) data has been presented in this paper. The high intensity rainfall has been compared with the rain gauges AED [8] and RIMCO (professional tipping bucket rain gauge, with corrections [3,4]). OTT Pluvio 2 [5] was not installed prior to 2016, so the data regarding low intensity rainfall data was compared, and on the other hand, the rainfall data from RIMCO rain gauge was not available.

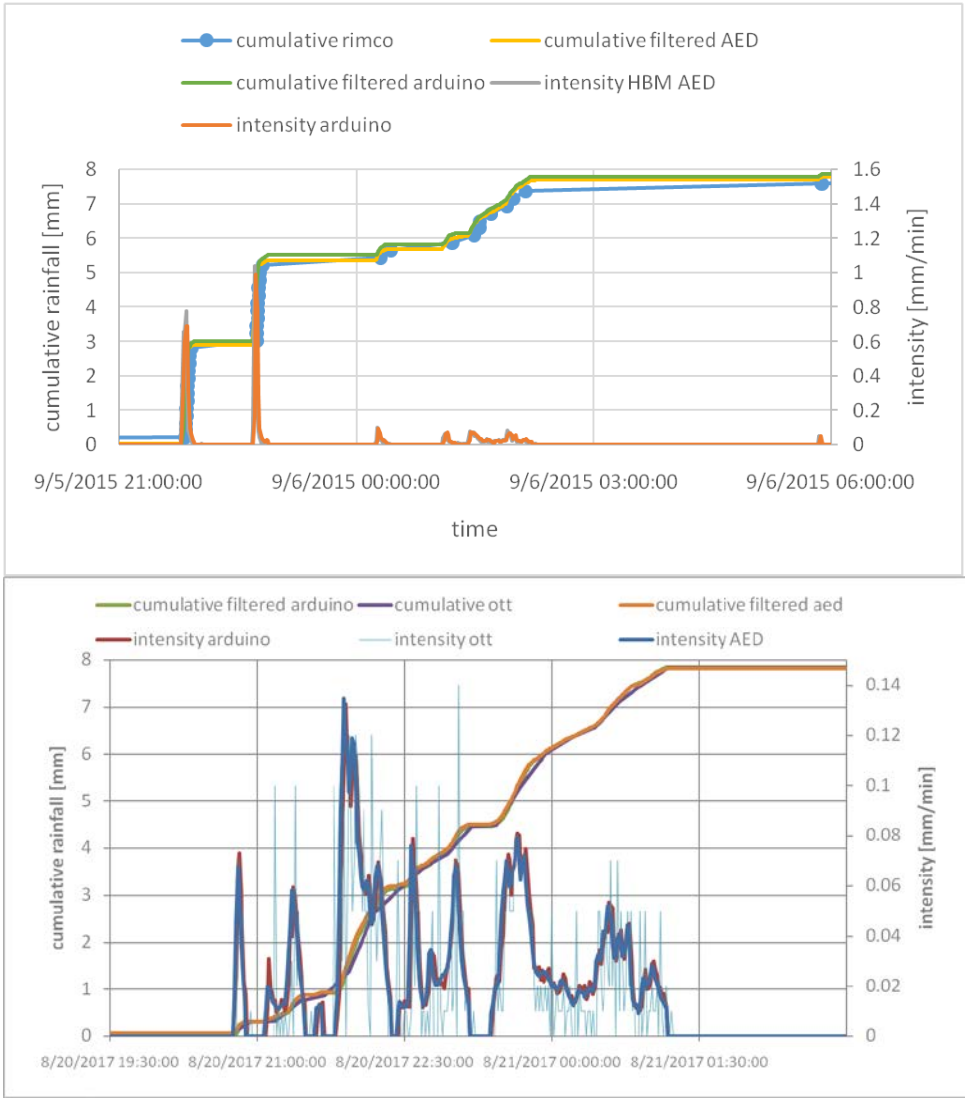

Figure 6. Data comparison of high (top) and low (bottom) intensity rainfall

4. CONCLUSION

According to the data graphs above (Figure 6), we come to a conclusion that the Arduino based rain gauge has satisfactory readings compared to the reference rain gauges. Next iteration should focus on improvement of the battery life and improvement of the data processing algorithm, as well as rain gauge calibration.

Having the low price of the Arduino based rain gauge in mind, it is obvious that the rain gauge meets the necessary reading accuracy when compared to the professional (commercial) rain gauges. This allows the user to collect the rainfall data in "smaller" projects or tests on places where no official meteo stations are available. However, this device should not be considered as long-term device due to its drawbacks, namely low accuracy class components, low resolution load cell with no temperature compensation, and acquisition system still suspect to dynamic force and vibration interferences.

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КАКО НАПРАВИТИПОУЗДАН КИШОМЕР ПРИХВАТЉИВЕ ЦЕНЕ

Резиме:*За потребе хидротехничке праксе неопходни су подаци о количини и интензитету падавина. Овим мерењима се стандардно бави Републички Хидрометеоролошки Завод. Међутим, честоти подаци нису доступни у траженој временској или просторној резолуцији па је неопходно поставити привремено властити кишомер. На тржишту је могуће набавити релативно јефтине кишомере са клацкалицом са незадовољавајућом резолуцијом и сумљивом поновљивошћу. Због тога је конструисан релативно јефтин кишомер на тежинском принципу. У овом раду описане су техничке карактеристике кишомера, као и његове могућности закоришћење у хидротехничкој пракси. У раду се дају и поређења добијених резултата са мерењима обављеним на знатно скупљим уређајима.*

Кључне речи:*Кишомер, хидрометеорологија, мерење, падавине*