Implementation of a Low Cost Software Oscilloscope in Remote Practical Works

ABOUHILAL Abdelmoula1, MOULAY TAJ Amine1, TAIFI Naima1, Abdessamad MALAOUI1

1Research team in electronics, instrumentation and measurements, Polydisciplinary faculty, Sultan Moulay Slimane University, Beni Mellal, Morocco

[a.abouhilal@usms.ma](mailto:a.abouhilal@usms.ma)

***Abstract- This paper presents the implementation of a software oscilloscope in a remote electronics laboratory. The architecture of this lab is based on the cooperation of two embedded systems, Arduino and Raspberry. The latter plays the role of a server in which we implemented a web page provided by NodeJs and the software oscilloscope using Processing; while the Arduino deals by measurements comes from the practical work card. The results of this approach will be compared by a real hardware oscilloscope. This architecture is beneficial for low cost labs and low bandwidth connections.***

# ***Key-words: remote labs, practical works, processing, software oscilloscope, electronic experiences.***

# INTRODUCTION

# Learning activities of technical disciplines in engineering education based on experiment [1]. Practical teaching is among the most persistent methods of education in the field of electrical engineering [2], [3]. And this, to develop the skills and critical thinking of students [4]. Several approaches have been developed to ensure the necessary resources of practical education, classical hands-on lab where access is local and resources are real, virtual lab when we have a local access and simulated resources and remote laboratories where there is a remote access and real resources [5].

# Online Remote laboratories allow remote access to the physical resources of practical manipulations [6], in order to minimize the financial burden on the one hand and to allow a large number of students to access the practical work and also It is very promising as it provides many advantages to know [7]: Accessibility for people with disabilities who need an unavoidable effort to move to the institution; Availability at any time and from any place in the world; Observability from where the manipulation can be followed by several people and even be recorded; Safety in such a way the material and the manipulator have no risk during a PW.

# Remote labs are based on the development of Internet and Information Technologies[8], both are considered as a great innovation in engineering education[7]. Electronics is a discipline that is based on practical work (PW)[9]; there are several remote laboratories that offer electronic online PW [10][11]. All of these labs rely on the use of costly Internet-based measuring instruments[9], [12].

# There are several laboratories that use emulated systems to minimize the cost of developing remote labs instead of using expensive servers [13]–[15]. In our work we used 2 embedded systems, Arduino and Raspberry. In this paper we propose architecture of less expensive practical work based on a software oscilloscope based on two microcontrollers; Arduino[16] and Raspberry[17], which his architecture is shown in the first paragraph. In the following paragraph the hardware part is presented include all parts of the discussed solution. The software part, NodeJs and Processing is presented in the next paragraph. Then, as results, a description of the software oscilloscope and its functionalities is presented.

# Materials and Methods

* 1. Used architecture

**Raspberry**

**Arduino**

**Practical Work Board**

**WebCam**

**Relays**

**User Interface**

**Switch matrix**

Data acquisition

Processing Data

Command

User data

Figure 1. Architecture of the proposed approach

* 1. Description of the material part

The architecture of our remote practical work is based on the cooperation of two embedded systems:

Raspberry: responsible for the main processing of data measured via Arduino [18]. It acquires the data via the USB serial port, and then it processes them with processing, in order to make them usable for the display. The measured signals will be displayed in an interface using a JavaScript module. In addition, Raspberry plays the role of a server that provides a web page to the user. This page contains command buttons that represent the status of relay commands and a webcam area.

Arduino: used to measure signals comes from the PW card, and then process them before sending them to Raspberry through the USB port. The Arduino treats the measured voltages with its analog gates thanks to the digital analog converter; after, part of the processing of its signals is done by the script implemented in the source code of Arduino. This, to prepare the data before sending them to Raspberry.

In addition, the PCB of the PW contains the editing of the manipulation, in our case a RC circuit of charge / discharge of a capacitor Fig.2. This card is controlled via a relay card that acquired commands through the Raspberry's digital outputs, in order to open or close the circuit in the TP card. These changes will be viewed from the webcam installed on the Raspberry to keep the interaction in real time between the user and the TP card.

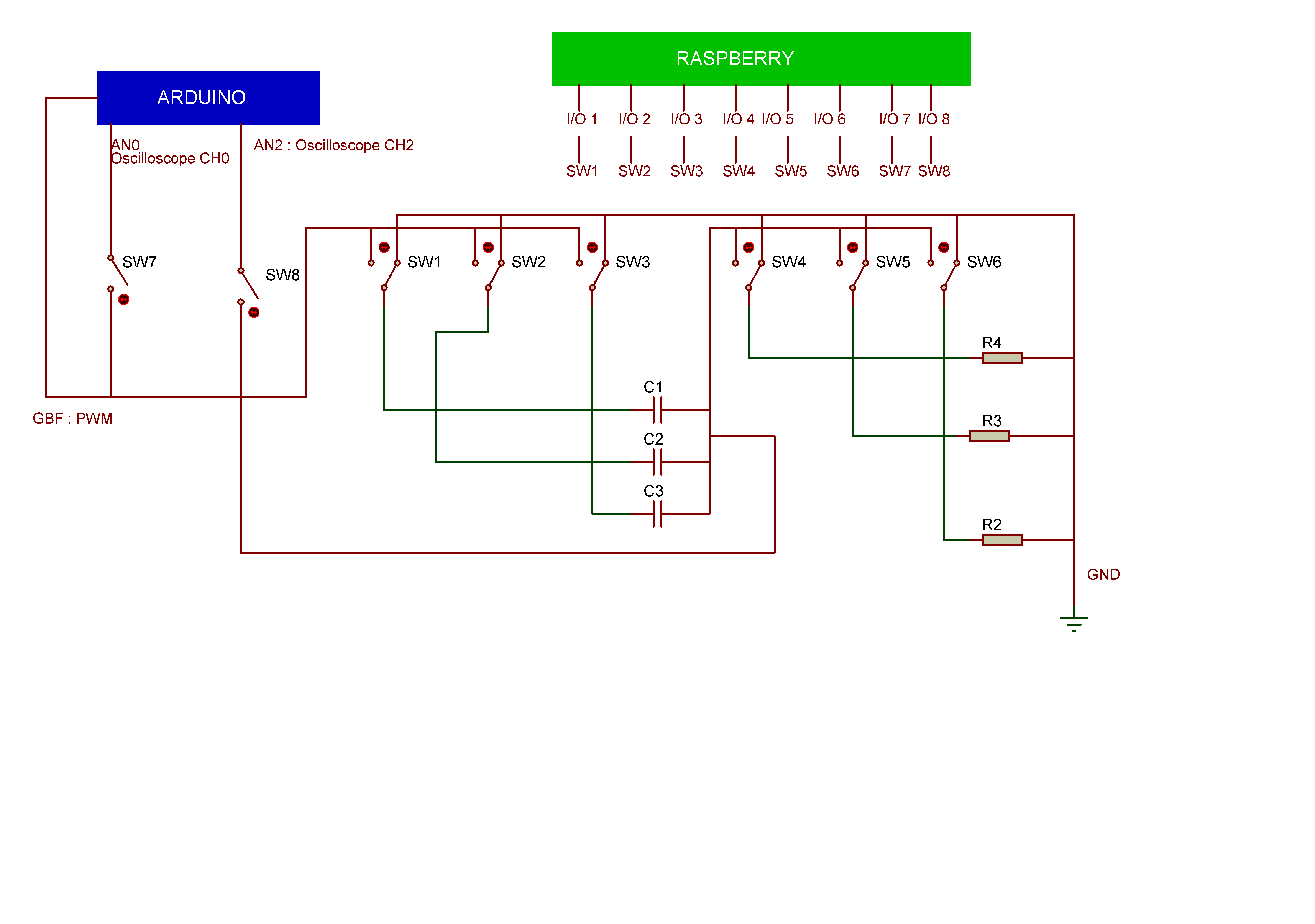


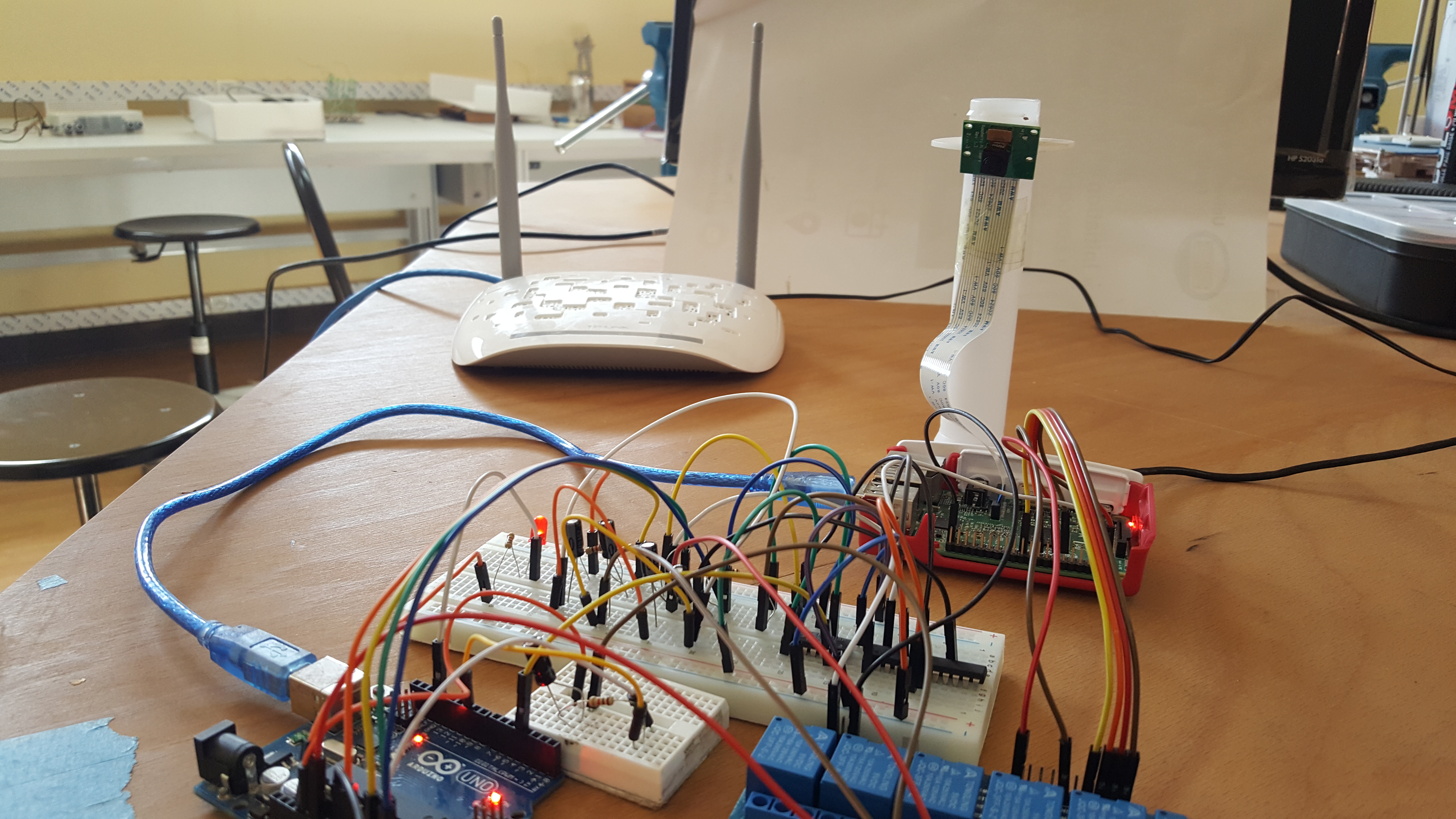
Figure 2. Electronic schema of the practical word

* 1. Description of the software part

The development of the oscilloscope is based on processing. The latter is an open source development tool that allows a computer to communicate with Arduino to back up, process, and display data.

Using the data received from Arduino via USB, processing can draw and make animations in 2 or 3 dimensions.

After implementing the program in both Arduino and Raspberry, and to ensure real-time communication, we send the signals to be displayed via a web interface, using NodeJs technology. The interest of NodeJs is to ensure real-time communication between the client and the server in an asynchronous way.



Realys

Arduino

Wifi

Raspberry

WebCam

Practical work board

Figure 3. Prototype of the remote practical work

# Results and Discussion

* 1. Description of the oscilloscope

This 4-channel oscilloscope allows the student to visualize and manipulate the following actions:

* The detection of frequencies ;
* Control and configuration of the 4 channels by varying the horizontal and vertical sensitivities;
* The backup of measured data in txt format for any use in another application.
* The generation of rectangular signals with PWM, with the possibility to change the frequency, the period and the duty cycle.
* The measurement of the value of resistors or capacitors.
  1. Comparaison between hardware and software oscilloscope

To test the reliability of our oscilloscope we compared its results with another hardware oscilloscope. Fig.4 and Fig.5.

Fig. 4 represents the signal of the charge / discharge of a capacitor, knowing that the rectangular signal of 5V is that of the input of the circuit, while the second signal is that of the output. These measurements are displayed via the software oscilloscope. However, fig.5 shows the signals measured with the hardware oscilloscope. Note that both instruments whether software or hardware, they have a likelihood.

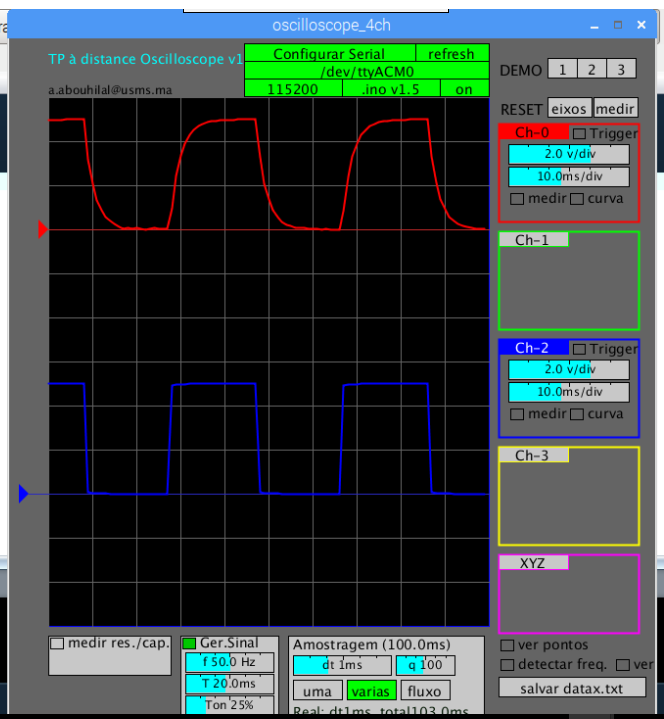


Figure 4. Visualisation of the Charge/Discharge signal on the software oscilloscope

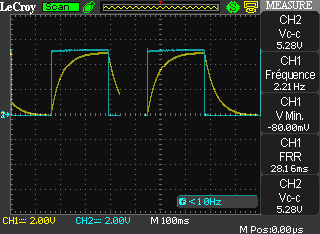


Figure 5. Visualization of the Charge/Discharge signal on the hardware oscilloscope



Figure 6. Used hardware oscilloscope

This software oscilloscope has several advantages to know that it is low cost, simple to integer view as it is flexible and portable, connected to the Internet and open source. But our solution is limited in terms of frequency, it depends on the frequency of operation and sampling of the embedded system used during data acquisition, is not suitable for negative voltages.

# Conclusion

This paper presents the description of the implementation of a software oscilloscope, in a laboratory of practical work, controlled remotely. This work describe, the architecture of the proposed solution, the embedded systems used, the software implemented as well as the integration of the oscilloscope within this lab. This fully open source solution minimizes the cost of developing this type of laboratory for electronics.

# FUTURE WORK

Future work will involve developing a complete oscilloscope to overcome the limitations of this version, improve bandwidth, use the negative signals, and develop an electronic card adaptation for voltage greater than 5V. On the other hand, we will test this solution in a full practical work scenario in order to solve other problems.

*References*

[1] G. Farias, F. Gomez-Estern, L. De La Torre, D. Muñoz De La Peña, C. Sánchez, and S. Dormido, “Enhancing virtual and remote labs to perform automatic evaluation,” *IFAC Proc. Vol.*, vol. 9, no. PART 1, pp. 276–281, 2012.

[2] A. Abouhilal, A. M. Taj, M. Mejdal, and A. Malaoui, “Design of a Remote Experience for Electrical Engineering Using Embedded Systems,” in *Proceedings of the 2Nd International Conference on Big Data, Cloud and Applications*, 2017, p. 100:1--100:5.

[3] M. Tawfik, E. Sancristobal, S. Martin, G. Diaz, and M. Castro, “State-of-the-Art Remote Laboratories for Industrial Electronics Applications,” *Taee*, pp. 567–572, 2012.

[4] R. B. Kuriakose, “South African Student Perceptions of Practical Laboratory Work – a Case Study from Digital Systems 1,” 2015.

[5] J. Djordjevi, “Remote Laboratory Development for the Education in the Field of Electronic Measurement,” vol. 1, pp. 37–44, 2009.

[6] M. Gourmaj, A. Naddami, A. Fahli, and M. Moussetad, “Integration of virtual instrument systems in reality (VISIR) OpenLabs with Khouribga OnlineLab,” *Proc. 2015 Int. Conf. Interact. Collab. Learn. ICL 2015*, no. September, pp. 793–797, 2015.

[7] R. Heradio, L. de la Torre, and S. Dormido, “Virtual and remote labs in control education: A survey,” *Annu. Rev. Control*, vol. 42, pp. 1–10, 2016.

[8] S. Shelke, M. Date, S. Patkar, R. Velmurugan, and P. Rao, “A Remote lab for real-time digital signal processing,” *5th Eur. DSP Educ. Res. Conf.*, pp. 266–270, 2012.

[9] A. Malaoui, M. Kherallah, L. Ghomri, G. Andrieu, T. Fredon, and D. Barataud, “New strategy for remote practical works in power electronics for embedded systems: Application in EOLES European project,” in *The Third International Afro-European Conference for Industrial Advancement, Advances in Intelligent Systems and Computing*, 2018, vol. 565, pp. 149–158.

[10] A. Abouhilal, A. M. Taj, R. Irkettou, M. Mejdal, and A. Malaoui, “Development and Testing of a Remote Laboratory for Practical Work Based on Embedded Electronics,” *J. Fundam. Appl. Sci.*, vol. 10, no. 4S, pp. 487–490, 2018.

[11] A. Malaoui *et al.*, “Implementation and validation of a new strategy of online practical works of power electronics for embedded systems,” *Int. J. Online Eng.*, vol. 13, no. 4, pp. 29–44, 2017.

[12] A. V. Fidalgo *et al.*, “The EOLES project remote labs across the mediterranean,” *Proc. 2014 11th Int. Conf. Remote Eng. Virtual Instrumentation, REV 2014*, no. 530466, pp. 211–216, 2014.

[13] M. Kalúz, L. Čirka, R. Valo, and M. Fikar, *ArPi Lab: A low-cost remote laboratory for control education*, vol. 19, no. 3. IFAC, 2014.

[14] C. A. Matarrita and S. Beatriz Concari, “Remote laboratories used in physics teaching: A state of the art,” *Proc. 2016 13th Int. Conf. Remote Eng. Virtual Instrumentation, REV 2016*, no. February, pp. 385–390, 2016.

[15] Y. Khazri, M. Moussetad, and A. Fahli, “Implementing a Remote experience for engineering education,” *Proc. 2015 Int. Conf. Interact. Collab. Learn. ICL 2015*, no. September, pp. 48–50, 2015.

[16] V. M. Cvjetkovic and M. Matijevic, “Overview of architectures with Arduino boards as building blocks for data acquisition and control systems,” *Int. J. Online Eng.*, vol. 12, no. 7, pp. 10–17, 2016.

[17] J. Bermudez-Ortega, E. Besada-Portas, J. A. Lopez-Orozco, J. A. Bonache-Seco, and J. M. D. La Cruz, “Remote Web-based Control Laboratory for Mobile Devices based on EJsS, Raspberry Pi and Node.js,” *IFAC-PapersOnLine*, vol. 48, no. 29, pp. 158–163, 2015.

[18] “arduino website.” [Online]. Available: www.arduino.cc.