Smart Real-Time RC Circuit Remote Laboratory Architecture

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***Abstract*—The smart remote laboratory experiments in engineering education became a useful tool as a great challenge for specialists. For to solve the problem of Expensive equipment and usually there are not enough devices or time for conducting experiments in a real lab. Other factors that prevent the use of lab devices directly by students are inaccessible or dangerous phenomena, or polluting chemical reactions. Setting up a new educational platform with remote laboratory experiments, many students from many countries can access them by web in order to complete, enhance their education in engineering . An advanced software/hardware flexible and real-time Operational Amplifier architecture brings additional strategies of learning and teaching, is presented in this paper. The software part is based on the html5,Canvas,javascript,Nodejs and the hardware : pcduino ,electronic device , agilent oscilloscope.**

Keywords— Remote Laboratory; operational Amplifier ; Rea-time ; Node js ; HTML5; javascript; socket ; canvas; pcduino ; linux ; e-learning; Agillent technology.

Introduction

Computer networks associated with increasingly interactive applications and mobile and accessible interfaces May promote innovative use in the field of practical scientific and technical training. Alternatives to-face formation and trainings such as remote laboratories. Can be a contribution to solving the problem of student massification Particularly in the countries of the South .

The practical work required for scientific training is often sacrificed in favor of purely theoretical teachings. Our distributed and distributed systems allow the sharing of material and human resources by bringing online practical work accessible in real time via the web. It is a computing environment complementary to the classical remote training. They allow learners to manipulate real devices (measuring or analyzing instruments - real or robotic mechanisms, ...).

Such facilities allow practical teaching to an increasing number of students Despite limited material and managerial resources. They can also be used to share manipulations between several academic institutions on a national or even international scale, and to make available to the various partners costly resources that they would not have access to.

The objective of the Cadi Ayyad university project is to develop an approach to develop remote laboratory work.

Two modes will be considered :

Laboratory mode at your house- (Lab @ Home). This mode takes advantage of the new technological solutions which provide the student with miniature kits and which make it possible to carry out experimental setups identical to those used in the classical laboratory. is a web interface allows student to control and see and command real device of laboratory.

Remote laboratory mode where equipment is centralized and all learners have access to these common facilities from different remote sites through computer networks. It is the part that receives the requests from the control interface and executes it.

I. Pedagogical Research

Engineering is a profession focused primarily on practice. The engineer concentrated on exploiting and modifying the fundamental resources available to mankind for the creation of different forms of technologies: energy, materials, and information. So During the last twenty years, laboratory work has been strongly marked by the arrival of the computer with its digital techniques and the development of distance education. The computer has opened new horizons for laboratory work through simulations, acquisition and numerical processing of measurements and presentation of results. Distance education was in turn the trigger for discussions on the objectives of laboratory work These discussions led to new understandings of the role of the laboratory in engineering education; This has launched a new challenge for the definition of the system of training of the new generations in engineering .

Many projects of Remote laboratory have been done to improve the system of E-Learning but among the reasons that push us to make a new conception we find :
-Educational and pedagogical standards followed in teachings:
(Realization an electrical diagram and schema is a skill so is must be realized by the student) . In the electronic field, to understand the running of some component electronic and the realization of a practical work requires the creation of electrical circuits, that is to say, it is the students who are to choose the components and link them for to get the schema of

the circuit and takes the desired measurements. But the current system does not give this opportunity to the student; we find just the predefined schema with only the switch or buttons that the student can be open or close. So we created an application that gives hand to the student to choose the component and be connected to realize their own schema.

-Laboratory management :

In the old system, for each practical work, the laboratory preparer must program a client-side application and a server-side program, and, likewise, to realize the real assembly of the specific circuit of that practical work in the laboratory so that the student can control remotely the TP real.

Since the electronic field contains many TP to achieve and realize, the preparer must for each TP repeat all the works. So this method is not efficient and requires much effort and time. Since our systems allows to realize any electrical diagram **by one program**, will solve this problem. More than that, in the existence each TP needs a pcduino card to orders the real assembly. So our system with a single card pcduino can do several TP even at the same time depending on the need, thanks to another application that will make the management of the laboratory easier by taking the appointment of the practical work for any student or researcher .

II. ARCHITECTURE AND TECHNOLOGY SYSTEM.

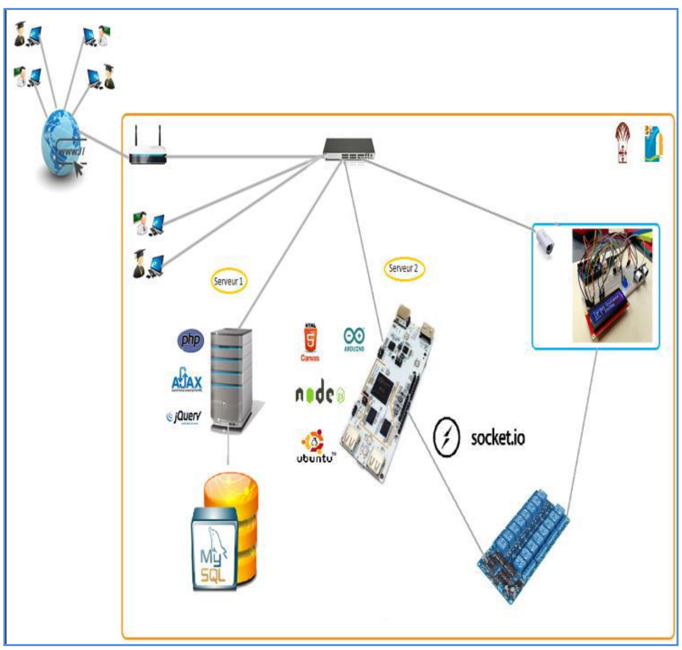


Figure 1:Architecture and technology system

In the diagram of Figure 1, there are two perimeters. The first is the web (Internet) and the second is the perimeter of the university (specifically the local school network LAN).

In the perimeter of LAN, we have two web servers, one containing the learning platform that represents the central faculty information system, where all information is found.

The second server is a **pcduino** that contains the application that will allow students to handle the practical work.

The process would work as follows: a teacher or teachers connect either using the Web or the local network; each teacher defines one or more TP, puts the theoretical part and the scenario after having made the TP reservation for all students.

On the other side, students connect using either the Web or the local network (Most of the time, students will use the web, because the use of web was among our goals from the beginning). If the student has a TP, he consults and reads the scenario, then he checks the reservation. If the reservation time arrives, he manipulates the TP; during this stage each reservation is destined towards the server 2 (pcduino card). If the reservation time elapses, the TP ends and the material resources are released for a future reservation.

2-1 Platform of management

For the management of the laboratory we have created a web application by the interaction of several programming languages (php, ajax, sql...) This platform is divided into 2 parts:

- Admin Part where the administrator organizes the laboratory by the management of students, using a set of criteria (branch, group, module...), and the creation of the niches and the appointments for the manipulation and particle work.

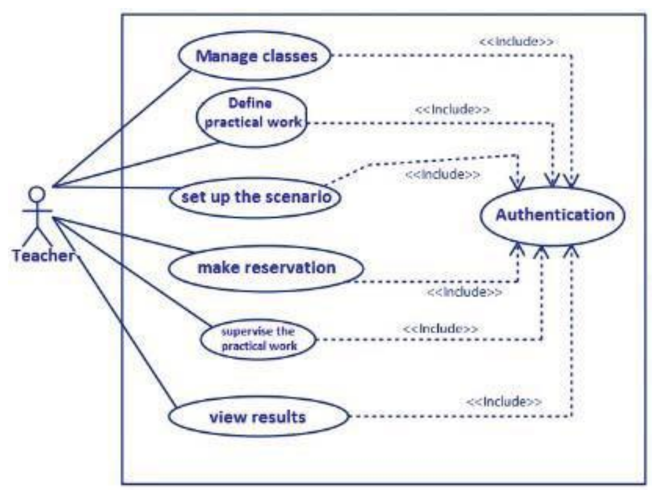


Figure 2: Use case of Admin

Actor : "Admin or Teacher":

• Authentication: the application checks that the teacher is what it purports to be then it gives the access authorization.

• Manage classes: allows teachers to manage classes, specialty and students.

• Define TP: enables teachers to set a TP, put his name, objective and theoretical part.

• Put the scenario: allows the teacher to work a practical scenario, which defines the steps to be implemented to make this work convenient.

• Make reservation: allows the teacher to create a reservation for each student to a specific practical work.

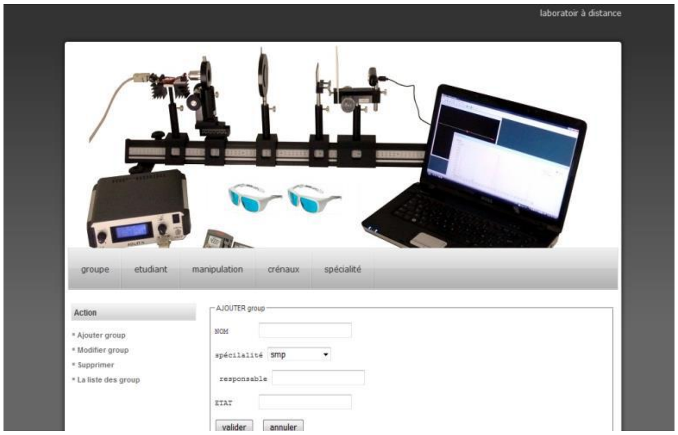


Figure 3: Application of management admin part

-The 2nd part concerns the client part in which the student, after authentication in the management platform, will see if he has an appointment for a manipulation; he will even know the date and time with which to start the TP. If the time comes, the link of the manipulation will appear and who will send the student towards the 2nd application that are the our electronic simulator in the web .

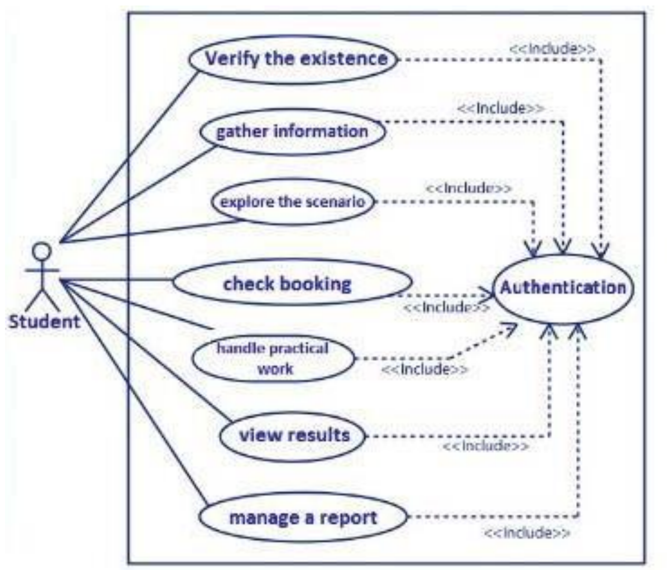


Figure 4 : Use case of student

Actor: "Student"

• Authentication: the application verifies that the student is what it purports to be and then gives the access authorization.

• Check there is a TP: enables student to check if he has a practical work.

• Gather information about the TP: enables the students to see and learn the theoretical work.

• Read the TP scenario: allows the student to read the script, to knowall the steps and details to bring up this assignment.

• Check the date of handling: allows the student to check the reservation practical work in order to know the exact time of manipulation.

• Handle the TP: enables the student to handle the practical work Using another application in server 2 (web simulator) but this will happen only when the reservation time for this student is checked.

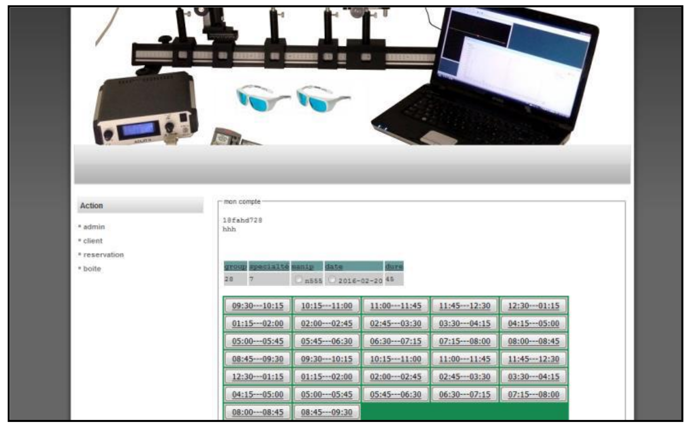


Figure 5: Management appointment of student

2-2 interface of control and command .

the student will achieve the electrical schema of the circuit and can control and order the real Assembly of laboratory via the web. The great technologies used in this application are **html 5** especially its suitcase **canvas**, Node.js, websocket (socket.io) and the pcduino card.

To have reactivity between the client and the application we used the canvas suitcase of **html5** that comes to replace the flash.

Figure 1 : html5 vs flash

Then this technology will allow to virtualizes the real practical work and realize the circuits by using the pictures and animation that will be the ways by which the student will manipulate and control the real TP.

To develop an application in html5 (<**canvas**>) for have a animation and flexibility to choose the device and link them requires using a lot of JavaScript. That is why we used the

Node.js technology that will allow to set up a web server on our electronic card pcduino (it's Also the card by which we will control the real circuit).
The advantage of using **Node.js** is that it allows running the java script in the server side instead of the client side and is based on the engine of google chrome V8 that makes faster the execution of JavaScript. This technology already used but what is new ,is in the socket.io library that allows the exchange of information between the client and the server: this library in the latest projects is used, but it does not operate the interest in this Library; they are only used for sending the request from the client towards the server, knowing that we can do just with Ajax because it actually allows the client and server to exchange information without reloading the page. But in Ajax it is always the customer who request and the server repe**a**ts. The server cannot decide by itself to send information to the client. So with Socket.io this has become possible, and we were going to exploit it since our server is itself our pcduino card by which we are going to protect the real circuit and device. If the voltage of the threshold levelis exceeded, then the server must inform the client to pay attention to the protected component and device.

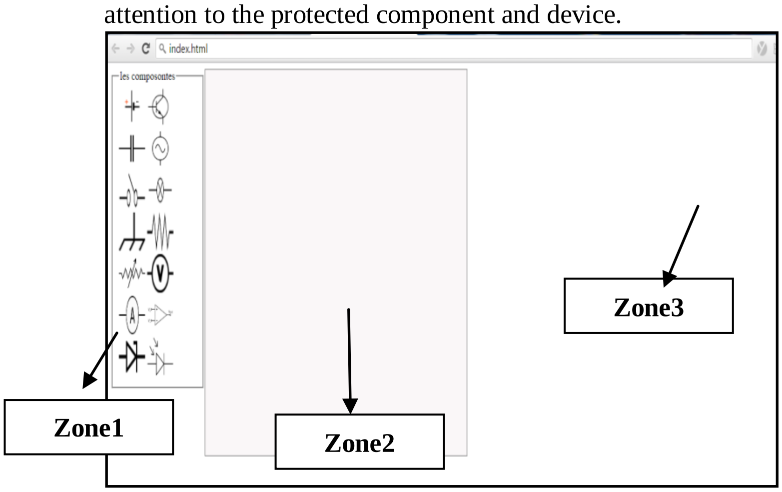


Figure 6 : control interface

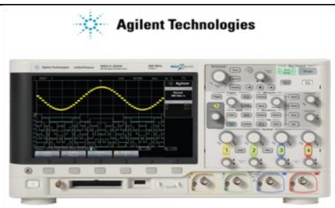
Zone 1: This zone contains all the electronic components that the student has to choose and works at.
Zone2 : It is in this area where the student must carry his electric scheme.
Zone 3 : This area will display the control interface when the student will choose the measuring tool or power because we will exploit the existence of some measure of material and source of energy configurable and controlled via the web from a web interface such as tools of Vision agilent

The laboratory must be equipped with a pcduino card and a board on which all the electronic components mounted depending on the given needs. These components are connected between them by relays; we will even exploit the existence some measure of material and source of energy configurable and controlled via the web from a web interface
In the **pcduino card** we will use the Node.js technology that will allow us to create an http server and the application of simulation. This card uses a Linux operating system, and from the Linux file system we can control and order the pins of pcduino to manipulate the assembly:
- GPIO digital pin: 18 I / O 3.3V
-Analog inputs: 2 x 6 bits 0-2V and 4 x 12-bit 0-3.3V.
- Analog outputs: 6 x PWM (2P "fast" in 520Hz - 8-bitand 4-pin "slow" in 5Hz - 20 levels).
So, in order not to overload the memory of the card, by to installer the set tools (python, pcduino, editor….) to program the card, we just used the library <FS> of Node.js which will allow access for the control file of the pcdiuno pins.The all in a single program (http server program and the pcduino control and command parts).
The files fixing the input or output mode are set in the Linux directory:
/sys/devices/virtual/misc/gpio/mode/
- Files containing / defining the state of the pins are placed in the directory:
/sys/devices/virtual/misc/gpio/pin/.

When the student chooses the electronic element and links them, for every link a request will be sent by the library **Socket.io** of Node.js towards http server which processes and hands over pcduino for the sake of controlling the relay.
Our system is designed to solve the problem of having to program every time an application for a lab TP and create an assembly for this TP. So our solution is in the web application that is like an electronic simulator, but the difference is that it is used in the web, and in the pcduino program and in an assembly which includes the electronic component which are connected together by relay.

III. DEVLOPMENT TRAVEL WORK OF RC CIRCUIT.

The Agilent DSO digital oscilloscope is an essential instrument of the electronics laboratory. It makes it possible to visualize variable voltages over time and to perform a certain number of conventional operations on these. However, like any measuring device, it is not without influence on the signal It measures.



An integrated Web server allows communication with the oscilloscope and To control it from a Java ™ -based web browser. It is Then it is possible to configure measurements, monitor signals, Capture screen images or control the oscilloscope to distance. Standard Commands (SCPI) commands Programmable Instrumentation, standardized commands for Programmable instrumentation) can also be sent to the local network.

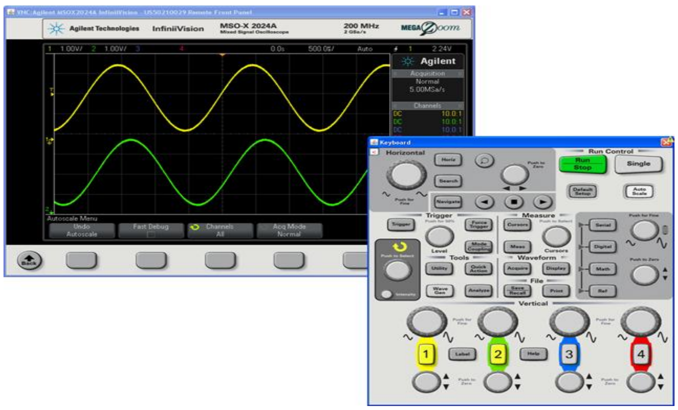


Figure 2: front panel of oscilloscope

It is an applet written by the java language. Which we introduced in our algorithm of the node js by using the frame of html5 .this applet we allows to control and command the oscilloscope via the web.

The Objective of this first travel work to familiarize themselves with the functions of the digital oscilloscope and generators (stabilized power supply and GBF);

- take advantage of it to carry out some revisions of electricity

I Description of the front panel

To the left is the screen, at the top of which the status line summarizes the configuration of the oscilloscope.

At the bottom of the screen 6 function keys (menu) are accessible after selecting one of the gray keys that Are in the right pane.These gray keys are grouped in 5 zones: "Horizontal", "Vertical", "Measure", "Trigger" and "Run Control"

With a USB key, you can recover the oscillographs (for example in bmp format by pressing Save / recall from the "Measure" menu .

II Visualization of a voltage

1. Automatic settings

Apply a sinusoidal voltage of 2.0 V of amplitude and frequency f = 200 Hz to channel 1. Press the Autoscale button. The setting of the sensitivities: vertical scale in V.div-1 and horizontal s.div-1 is done automatically. These values are displayed in the status bar at the top of the screen with other indications.

2. Manual settings

It is sometimes necessary to refine the settings manually. Press 1 to select channel 1, a first menu appears at the bottom of the screen (the channel is switched off Service if you press 1 again).

Note: It is possible to display the opposite of the voltage by pressing the Invert key

2-a) Setting the time base: "Horizontal"

The horizontal sensitivity (or sweep speed) is changed by turning the knob To the left of the zone. Observe it on the status bar.

Note: by pressing the button or Horiz and End, you can change the speed of Scanning in smaller increments.

The entire curve can also be shifted horizontally by turning the Button on the right of the area, the time offset value is displayed on the Status line.

2-b) Setting the vertical sensitivity: "Vertical"

Use the VOLTS / DIV rotary knob to change the vertical sensitivity of the channel.

Note: here again it is possible to modify it in smaller increments in Pressing the rotary knob or pressing the End key of the menu after pressing 1.The signal can also be shifted vertically by using the rotary knob Vertical POSITION.

The value of a voltage indicating the difference between the center of the screen and Reference of the mass

(Its symbol appears shifted to the left of the screen).

3. DC mode or AC mode

- Act on the generator to add a DC component to the signal so as to obtain a sinusoidal voltage varying between -1 and +4 V.
- Give the amplitude and mean value of the voltage.
- Switch from DC mode to AC : 1 and then Coupling.

What do you notice?

The CA mode can be useful if you are only interested in the variable part of a voltage (oscillations around a non-zero average value for example).

Stay in AC mode and see a rectangular signal with a frequency below 50 Hz (be careful, at low frequencies the Autoscale key may not work properly).

What is going on ?

III Measurements ("Measure" area)

1. Automatic time and frequency measurements

Change the GBF settings to apply a sinusoidal voltage with frequency f = 100 Hz and

Of amplitude 2.0 V on channel 1 of the oscilloscope:
U (t) = Umax.cos (wt + j) = 2.cos (200pt + j)
• Press Meas
• Then select the Source studied (channel on which the measurements are made) then Type and
(Or) the rotary knob marked? To select the operation performed: for example Freq and
Period correspond to the measurement of the frequency and the period of voltage.
• Pressing Add Measure then displays the result on the right side of the screen.

2. Automatic voltage measurements

Press Meas again and check the role of the keys:
• Amplitude: gives the value of the peak-to-peak voltage: twice the amplitude Umax if no offset.
Note the difference between the amplitude definition and the device definition.
• Average N cycle: gives the value of the voltage (over N whole periods) mean = DC component
Of a periodic voltage of period $T=\frac{1}{f}$
Is its OffSet.

$<u(t)> = \frac{1}{T}\int_{t0}^{t0+T} u(t)dt$

- Check the mean value of a sinusoidal, triangular or slot voltage, then with continuous component.

- CA eff N cycle: gives the true value of the alternating voltage

  $U_{eff} = \sqrt{\frac{1}{T}\int_{t0}^{t0+t} u^2(t)dt}$.

- For example, keeping Umax = 2.00 V, measure the effective voltage :

-For a sinusoidal voltage without DC component. Check that: $U_{eff} = \frac{Umax}{\sqrt{2}}$

-For a triangular voltage without a DC component. Check that: $U_{eff} = \frac{Umax}{\sqrt{3}}$

-For a rectangular voltage without a DC component. Check that: $U_{eff} = U_{max}$

-for Vmax (Vmin) which gives the maximum (minimum) value of the voltage.

3. Manual measurements

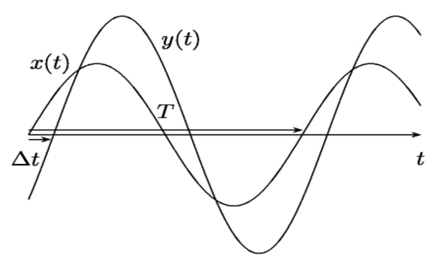
It is possible to perform measurements on the abscissa or on the y-axis with the cursors.
• press CURSORS, in the "Measure"
• select the cursor you want to move (X1, X2, Y1 or Y2)
• turn the rotary knob near the CURSORS key and read the cursor position or difference
Between the positions of the two cursors.

4. A particular case: measurement of a phase shift

Make an RC circuit with R and C variable, and set to R = 10 kW and C = 0.1 PF. Feeding by voltage Sinusoidal with frequency f = 100 Hz and amplitude 2.0 V.
Let x (t) be the voltage across the generator and y (t) the voltage across the capacitor

4-1 Measuring in Scan Mode

The preceding method does not make it easy to know the sign of the phase shift (it depends on the direction of
Course of the ellipse), it must be determined in sweep mode.
The sign of j is obtained by looking at whether x (t) is ahead or behind y (t).



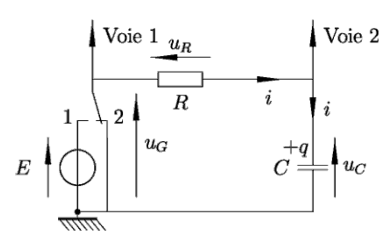
- What is the sign of the phase shift in the figure opposite?
- Propose a method for determining j and its sign at Using the Dt measure.
- Determine again, with this method, the phase shift in The previous RC circuit.

4-2 Direct Measurement

- The oscilloscope gives $\emptyset_{1/2}$ the phase shift of the applied voltage On channel 1 (x (t) here) with respect to that applied in channel 2 (y (t) here).
- Think of changing the sign or reversing the paths to get 'as it was defined Previously.
- Finding the phase shift in the RC circuit

Application: response of a series RC circuit to a voltage step.

2.a) *Mounting*



Make the assembly shown opposite.

• Stabilized supply set at E = 5.0 V.

• The resistor and capacitor are decade boxes with R = 10 kW and C = 0.1 PF.

• K is an inverter switch: if K is in position 1, the Capacitor will charge and it will discharge if Position 2.

2.b) Theoretical study

Find the differential equation of the circuit in u_C (t), then deduce u_C (t) considering that the capacitor is Initially unloaded. The theoretical value of the time constant t of the circuit is calculated.

2.c) Settings and operation

One wants to "capture" the charge of the capacitor to the oscilloscope, it is a non-periodic phenomenon.

• Verify that the vertical sensitivity of the oscilloscope channels allows you to view u_G on channel 1 and u_C (t) In channel 2 in full (voltages between 0 and E) and on the entire screen (offset the ground line Of the 3 V channels downwards).

• Set the scanning speed in relation to the calculated t value: in a first step,

View a full load on screen:

• Check by tilting K to position 1 and then 2 several times, you should see momentarily the load.

Source	Mode	Déclenchement	Coulping.	Front (montant ou descendant)

• Several attempts may be necessary (fully discharge capacitor (K in position 2)

Between each test), use the rotary knob in the "Horizontal" area to shift the curve to the left if necessary.

• Check the order of magnitude of t by measuring the rise time directly to the oscilloscope: Meas then Climb.

• When you get a nice full charge (call me to check), print the curve in

Using the print Screen key and the desktop printer.

• Graphically determine the value of τ by the tangent at origin method .

So The student must choose the appropriate components

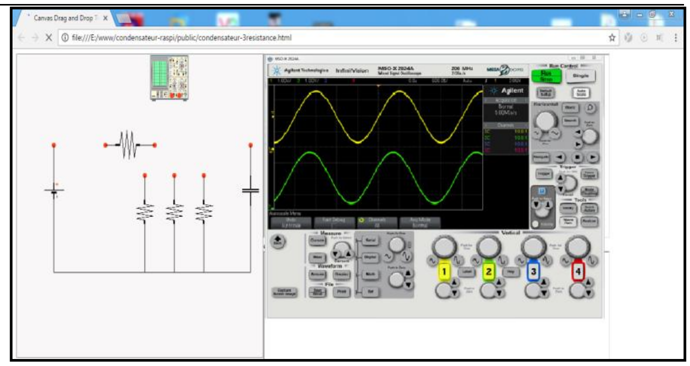


Figure 3 interface web of control and command

After he will make the connections and take the measurements

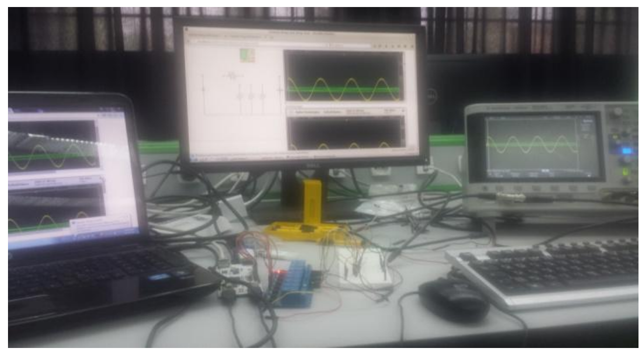


Figure 4 real circuit in laboratory

Conclusion

The paper demonstrated a new way of building remote experiments to solve a set of problems in the laboratory management and in educational, pedagogical standards followed in teaching. This solution is an advanced real-time and flexible software/hardware. It describes both the software architecture based on the two applications: management platform and the application of simulation use of Node.js written in JavaScript and hardware architecture, especially the pcduino card and a set of electric devices.

So our Remote laboratories offer students access via the Internet 24 hours / 7 days. They also open the possibility of sharing expensive laboratories with other institutions, local or abroad. Instead of **having** each institution developing and executing the same types of laboratories, Remote laboratories can be shared globally where only access to Internet is available.

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