Leveraging iLab to serve client-less online laboratories for electronics

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***Abstract*— This paper describes the study of creating client-less online interfaces for laboratories served through the iLab publishing system. Given the increased usage of the iLab Shared Architecture, for example the launch of the new iLab Europe website (http://ilab-europe.net/) it seems like a good opportunity to study the potential of the iLab software. At present, iLab interfaces are being built using various third party plug-ins, however, because it is really a web application these shortcomings can be eliminated by using standard front-end programming techniques. By client-less interfaces we mean any web interface that is served on the web which does not require any installation for the end-user other than a modern web browser. The support application for this paper features three remote experiments that range from the analysis of a light dependent resistor to the study of filters. The main piece of hardware used is the ME3200 Electronic Instrumentation and Measurement toolkit developed by Dreamcatcher. The device is an educational aid for studying electronics. Measurements and powering will be handled by Agilent devices. These devices can be controlled by a computer, therefore are an important part in enabling remote-control on the experimental set-up, by means of LabVIEW applications and various back-end web programming technologies.**

***Index Terms*—iLab, Online Laboratories, HTML5, Ajax**

I. Introduction / iLab

The goal of this work is to prove that modern front-end web development techniques can be successfully deployed in iLab, and provide much needed flexibility for laboratory users. The iLab software suite provided by MIT allows educational organizations to publish online laboratories for their students. These laboratories can be accessed and performed remotely. In short, this is done by using a network of Laboratory Servers that are managed by a Service Broker, which the users can access and perform the desired work. iLab is open source ASP software that provides a user system, a scheduling system and a laboratory listing, amongst many other features. As such, the publisher can create an application that runs under the authentication and scheduling system of the iLab platform using ASP. The support application is packaged in a Laboratory Server that will be accessible through the iLab Service Broker. The iLab instance at Transilvania University can be accessed at the following URL: http://ilab.unitbv.ro/.

The reason client-less interfaces are so important is their use in mobile devices. The web is currently going through a transition from viewing and using desktop websites and web applications to their mobile and touch counterparts. Usually, mobile may refer to small but Internet capable devices such as mobile phones, and touch may refer to the bigger tablets or net-books. While there's a good argument that one may have some difficulties trying to perform laboratory work on a small mobile phone screen, performing such activities on tablets is a perfectly valid option. The problem facing these devices is that their manufacturers frown upon third party plug-in content being served over the web. Apple's iDevices being the major example here (they do not support Flash). The solution is using web standards that are proven mature technologies that will do a good job in offering a compelling and immersive interface to every device that it is served to.

Because iLab is in essence a web application written in ASP, there is no reason it can't serve normal HTML5 rich interfaces programmed in JavaScript. The rule of thumb is that if it works on a desktop environment where the only required installation is a modern web browser, it will work on any capable modern mobile device such as iOS or Android machines.

There are many reasons a university would choose to deploy such a solution. For example each student can access the laboratories online, on their own schedule, and they can work on their own, without the need to share the hardware with other students during normal laboratory hours. iLab is a very good fit for this scenario because of its scheduling and reservation systems. Another example would be students with limited mobility, or students that are geographically limited; by using remote laboratories every student gets a chance to study.

An important aspect in remote laboratories is the need for them to closely resemble the hardware they are using. The designs featured in this work offer solutions to this issue.

II. Hardware

The ME3200 is a ready-to-teach package targeting 1st or 2nd year undergraduates. This solution focuses on electronic instrumentation and measurement techniques. It comes with teaching slides that can be used in preparing the students to understand the subject before doing the laboratory work. The training kit consists of sensors, signal conditioning circuits, digital output circuits, and a resonant circuit; these allow students to

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explore the functionalities and applications of typical end-to-end measurement systems.

The purpose of this work is to make the board available for remote experimentation over the Internet. To make this possible, some modifications have been performed on the standard set-up, as can be seen in the following figure:

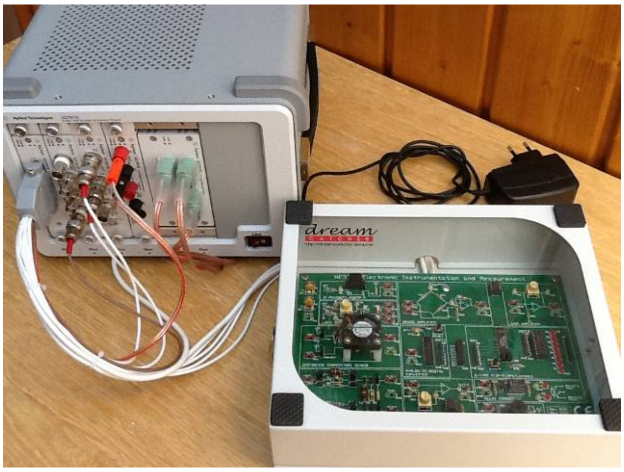

Figure 1 – The web enabled ME3200 and the Agilent measurement equipment

The Courseware board provided by Dreamcatcher has many components arranged in easy to see modules that are suitable for teaching electronics to students. For example there are several sensors available, such as an IR proximity sensor, a light dependent resistor and a centigrade temperature sensor. Additionally, there are the signal conditioning circuits such as the Wheatstone bridge, a current amplifier and a non-inverting amplifier and a voltage comparator. There are also digital output circuits such as D-type flip-flops/latches, mechanical relays and a buzzer. The board also houses a resonant circuit for studying filters and an analog to digital converter.

Some of the components enumerated above cannot be used in remote control over the Internet. For example the IR proximity sensor, the mechanical relay and the buzzer will not work for obvious reasons, as the operator needs to be physically there to use them. However, these do work as hands-on experiments, even in the altered version of the board.

At this stage we propose three laboratory experiments based on the modules available on the ME3200. The first experiment will study the light dependent resistor, the bridge current amplifier and the voltage comparator. The second has two parts, the first part will study the temperature sensor and the second part will study the gain amplifier. The third experiment will study the resonant circuit. Because all these need to be controlled over the web and no hands-on set-up of the board is possible, moving from experiment to experiment will be facilitated by the Agilent U2751A 4x8 2 Wire Switch Matrix.

The ME3200's power requirements aren't suited for online control, so, to solve this issue, an independent transformer is used that can power the board directly from a normal wall socket. In normal operations mode, the board needs two different voltages from its power supplies, however in this set-up it only requires the one transformer. This has the added benefit of not needing to control power for the board with the switch and also to free up the power supply that can now be controlled in order to provide inputs to the various experiment blocks available.

Variable voltage input will be handled by the U2722A Modular Source Measure Unit which has 3 outputs that are connected to various points on the ME3200. It is used as a DC power supply as it can fit in the USB Modular chassis perfectly. Signal generation required for the resonant circuit will be provided by the Agilent U2761A Function Generator. Measuring output voltage will be handled by the Agilent U2741A Multimeter which will be switchable to multiple measurement points on the board. Signal measuring will be handled by the U2701A Oscilloscope, which offers two channels for measuring. Finally, all the components fit nicely in the Agilent U2781A Modular Products Chassis that can connect to a PC using an USB cable, thus enabling all the instruments to be controlled via LabVIEW and ultimately allowing control of the ME3200 over the Internet as LabVIEW can be controlled online. This takes this research a step closer to being able to provide a ready to deploy solution for teaching basic electronics based on the ME3200 courseware. These Agilent instruments can also be seen in Figure 2.

III. AVAILABLE EXPERIMENTS

This work proposes three experiments deriving from the ME3200 laboratory sheets that Dreamcatcher provides with the board. The following figure shows an overview of the board, for reference.

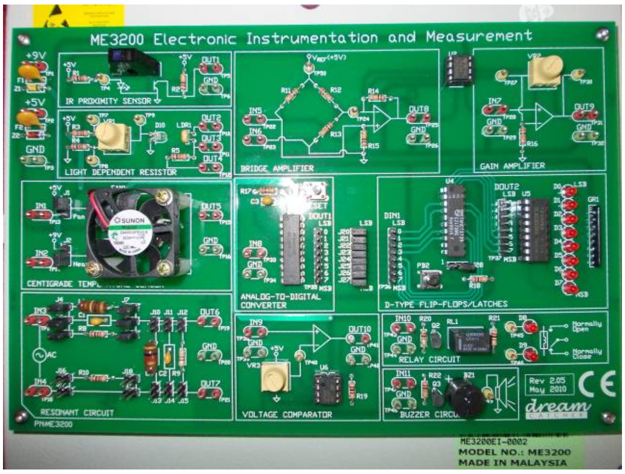

Figure 2 – Birds-eye view of the ME3200 board

A. Studying the Output of an LDR (Light Dependent Resistor)

The first experiment makes use of the Light Dependent Resistor, the Bridge Amplifier and the Voltage Comparator modules available on the ME3200. For this experiment one of the outputs of the power source is connected to the TP9 input on the board and modifying the voltage output will make the D10 LED emit light. The LDR will generate voltage depending on the light variations and its output can be measured at OUT2. The output of the LDR is also connected to IN5 which then helps studying the Bridge Current Amplifier by seeing how much it amplifies the current generated by the LDR. Users can measure and analyze this difference. The output of the amplifier is measured at OUT8. Last part of the experiment will demonstrate the use of the Voltage Comparator by providing a fixed voltage to compare against the amplified voltage (TP40). The output of the comparator can be measured at OUT10.

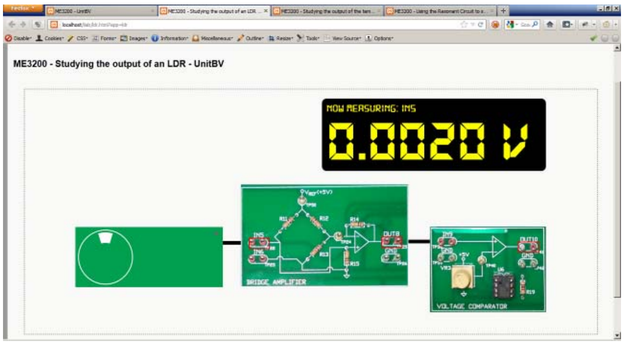

Figure 3 – The online interface for the experiment that studies the LDR

The figure above illustrates the interface for this experiment in action. The user can select one of the three points to measure the voltage by clicking on hotspots on the images. Each hotspot is located on the image over the actual measuring points on the physical board, as seen below.

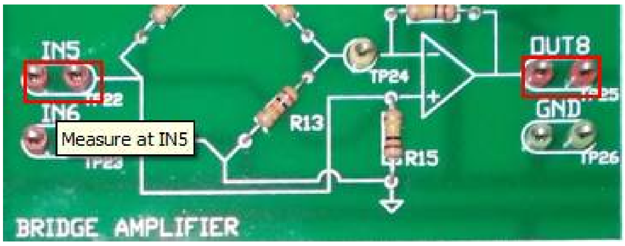

Figure 4 – Clicking on one of the hotspots will instruct the application to measure a certain point and display the measurements in the digital display

This should allow the user to understand that those are points where he can use a physical voltmeter to measure voltage in real life. Not shown in this picture is the LDR module available on the board (left). When not in input mode, the image shows the actual circuit of the module. The user needs to click on the potentiometer image to enter the input mode and adjust voltage on the LDR.

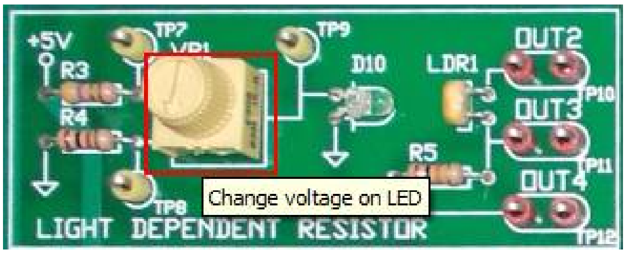

Figure 5 – The user would click on the hotspot over the yellow potentiometer to enter the input mode shown in Figure 3

All the data being received and sent from the interface is live.

B. Studying the Output of a Temperature Sensor

The Centigrade Temperature Sensor module on the ME 3200 is built around a temperature sensor, a fan and a heating element. It is designed in order to allow fast changes in the temperature measured by the sensor. Additionally, this experiment also studies the Gain Amplifier module, implemented by using a non-inverting amplifier.

The first part of the second experiment deals with the temperature sensor. The U2722A Modular Source Measure Unit has three outputs. One is used in the previous experiment while the other two are connected to IN1 and IN2. IN1 controls the fan and IN2 controls the heating elements. The temperature sensor on the ME3200 can output 10mV per centigrade and by varying either the temperature or fan speed the output of the sensor can be measured at OUT5.

The second part of the experiment will study the Gain Amplifier by analyzing the output of the temperature sensor and amplifying it. OUT 5 is connected to IN7, and the amplifier is hardwired to amplify by 10. The input voltage can be compared to the output voltage which can be measured at OUT9.

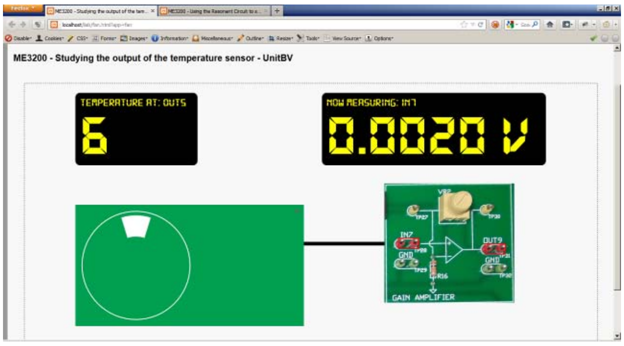

Figure 6 – The online interface for the experiment that studies the temperature sensor

In the figure above, we can see two points of measurement for voltage on the right circuit and also a reading of the temperature. The hotspots at IN7 and OUT9 are also visible. Similar to the previous experiment, the user can click on them and switch the physical measurement points.

Not shown in the figure is the fan module, seen below:

Figure 7 – The user can click on either of the visible hotspots and will be presented with a potentiometer to change voltage on either the fan or the heating element

C. *Using the Resonant Circuit to Study Filters*

The third experiment will use the resonant circuit to study filters. The Function Generator output will be connected to IN3 and the output of the circuit can be measured at OUT6. The signal will be viewable live in the web interface and the user can evaluate and see the difference in the input and the output. The U2701A Oscilloscope has two inputs, one will be connected to the output of the generator and the other one measures OUT6. Thus, the input and entry signals can be easily compared. As can be seen in the following figure:

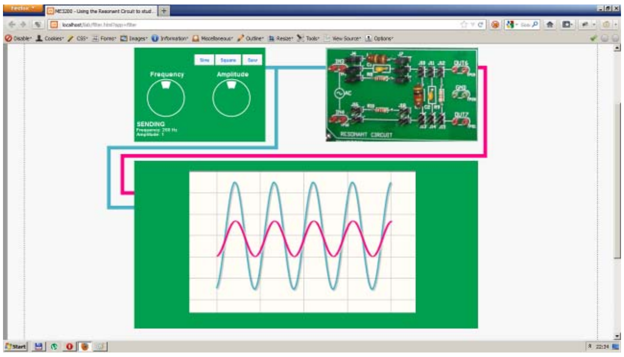

Figure 8 – Studying filters by comparing the original signal with the result

Note the blue and pink lines, the blue indicates the original signal (as connected on the physical board) and the pink indicates the filtered signal. The color coding allows the user to easily identify which of the signals is his original and which is the filtered one. The user can adjust all the features of the Signal Generator, as seen below:

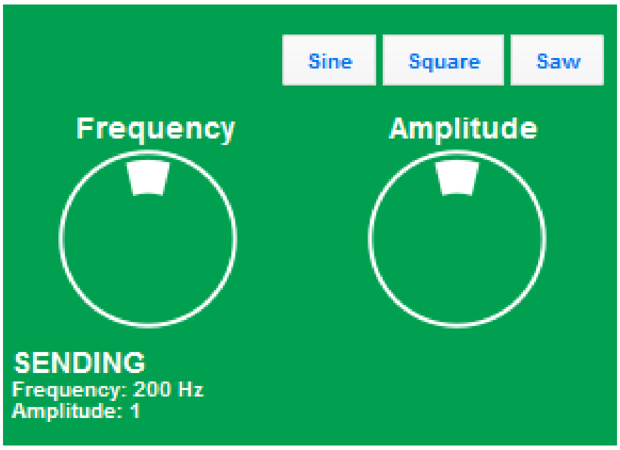

Figure 9 – The user can adjust frequency, amplitude and set the signal shape. The data sent to the instruments is live and changes in the signal will be seen immediately.

There are no hotspots on this experiment because the connections are hardwired on the board at this stage.

The controls for all the experiments have been designed in such a way as to minimize the fact that this is not a hands-on experience. Manually changing measuring points and the circular potentiometers should engage the student in similar way that real instruments do and prepare him for working with them.

All these interfaces are using modern front-end technologies such as CSS3, HTML5 (particularly the HTML5 canvas element) and also modern JavaScript trends such as the module pattern. It is very easy to roll out a new experiment if needed, as there is a central communications function which can have various behaviors plugged into it. This can serve new experiments, and the model can be re-used for experiments on other equipment too.

IV. LabVIEW

All the data acquisition requirements are handled by National Instruments LabVIEW, which makes communicating data between the website and the hardware possible. Each experiment detailed in the previous chapter relies on a LabVIEW VI to process and handle data. These VI's are built using an API built for communicating with websites.

Creating a VI for another experiment is extremely easy as the API VI's are very flexible and general which can allow rolling out a new VI for a new application in less than an hour.

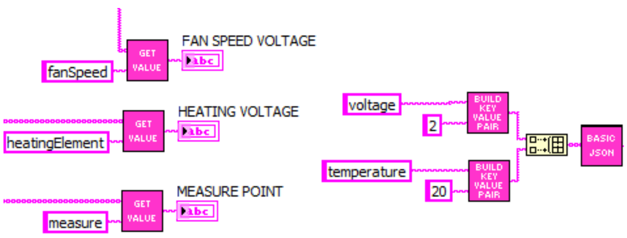

Figure 10 – API VIs that decode (left) and encode (right) data coming in and going to the interface

The data coming in as a piped string from the website can easily be decoded by using a key name and extracting the value being sent. The data going out will be encoded as a one level JSON string by supplying a key and a value. A lot of data can be sent. The picture above shows a section from a "static" (not connected to hardware) version of the temperature sensor experiment VI.

LabVIEW is the perfect environment for performing data validation on the information coming in from the website. It needs to make sure the values do not exceed the limits of the hardware to avoid damage.

V. Conclusions

It is possible to create Lab Servers for iLab by using only open-web technologies, however a tighter integration and an easy installation procedure is to be desired. The first step towards an easier installation is a more efficient communications system, which is planned for the future and will take advantage of new LabVIEW features.

At the same time it will be mandatory to push the boundaries of online laboratories for mobile clients (at least tablets for their ample screens). The iPad might be the first target for such tests.

In the end, if further research is successful, developing iLab interfaces for other educational institutions is not out of the question as it will most likely be a lucrative field given the continued development of the iLab software and the rising importance of web standards.

Acknowledgment

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