Switching Matrix Architecture For Flexible Remote Experiments Of Circuits Structuring In Electronics And Electricity While Using An Intelligent Algorithm

Yassine Larbaoui, Ahmed Naddami, Ahmed Fahli

Abstract : This paper presents the development of a switching matrix architecture within VISIR system for flexible remote experiments in electronics and electricity while relying on an intelligent algorithm at the software level for experiments control and monitoring through internet. The switching matrix is relying on a developed electronic board topology to enable the interconnection between any two components on VISIR system for remote circuits structuring. The developed intelligent algorithm at the software level enables to have a dynamic control and monitoring on circuits building within VISIR system while respecting the electrical limits of using the current and voltage, where the remote control and monitoring on electrical and electronic components within the switching matrix architecture. The developed switching matrix architecture and the developed algorithm enable to have flexible remote experiments and resilient control on circuits structuring for e-learning purposes, in addition of having more circuit combinations of experiments by offering the possibility of connecting any component to any other component on VISIR system.

Index Terms: Circuits structuring, e-learning, electronic board, flexible remote experiments, intelligent algorithm, matrix architecture, remote control, remote lab.

1 INTRODUCTION

THE continues evolutionary process of development of ITs (Information Technologies) has produced significant improvements and revolutionary jumps in various fields of industries, finance, business, health, communication, management, education, etc. As a result, educational establishments and learning frameworks have grown and evolved rapidly by adopting the concepts and tools of e-learning and remote laboratories, which is a major result of the corporation between telecommunication technologies, educational pedagogies and learning resources [1], [2]. E-learning has become a principal aspect and mainstream in the various fields of education, and it has been massively involved and integrated in higher educational sectors of United Kingdom, United States, Russia, Germany, Australia and other countries from different continents around the world. The aspect of provided service quality of e-learning systems has attract a considerable amount of research work and attempts of assessment and evaluation [3], [4]. A considerable number of researchers and investigators have tried to determine the responsible factors and variables of e-learning success, to optimize the potential yield and effectiveness of distance education while relying on these information systems [5], [6]. The major parts of these researches and studies have conducted their evaluation processes on different entities and keys of e-learning success [7], each one individually and separately from others; ignoring the significant synergistic impacts of these factors and entities while interacting between them and influencing each other [8]. Moreover, other orientations of research work and studies have treated the links and relationships between the quality factors of e-learning, the usage of e-learning systems and/or satisfaction of their end users [9], [10]. The significant amount of studies and research papers on e-learning, distance education and online experimenting have considerably contribute in evolving the pivotal success factors of e-learning. From many of these factors, there is the quality of used resources and systems, the quality of provided information and content , the quality of provided services through the internet, in addition of the interactivity, satisfaction and content usefulness [11], [12]. However, the excessive number of assessments and evaluation measurements among dependent and independent variables presents itself as the main challenge of current researches, toward developing a successful general model of e-learning and online experimenting. There is an essential necessity to have a comprehensive model about the multiple levels of e-learning success and their incorporated factors, variables and parameters [8].

E-learning systems are, basically, web-based information systems that implicate human individuals (such as students, professors and instructors), and nonhuman entities such as learning management systems and educational contents (courses, quizzes, exercises, etc.). It is important to investigate multiple levels and dimensions of successful interactions between the provided educational services and resources of these information systems, and their potential benefiters of students or other potential users. Laboratory’s practices of in-place experimenting represent the heart and leveraging pillars of engineering education. They open the way to shape and transform the bare knowledge into tangible tools, utilities and technologies exploited to the benefit and welfare of their users. There are four principal known categories of experimenting laboratories [13], [14]: hands-on laboratories, simulation based laboratories, virtual labs and remote laboratories. Hands-on laboratories are the most known and popular category in educational fields; they require the physical presence of human individuals (students, professors, instructors, etc.) and the experimental instruments and materials at the same local place. They provide their users of students with the clearest tangible experiences at the level of physical interaction and

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manipulation. However, their inconveniences of requiring high monetary investment, requiring more maintenance work and requiring more local spaces and infrastructures; stimulate the consideration of other supplementary resources or alternatives. Simulation based laboratories and virtual labs are simply imitators, they depend on software mathematical models and virtual resources of interfaces and systems, which may weakens the experimental reference to physical interaction with real instruments and equipment; if they lack high levels of interaction and high precision of experiments execution. Remote labs are physical labs, similarly approximated to hands-on laboratories, in addition of supporting online access and remote control on experiments. Their surplus convenience is their exploitability through the internet while providing multiuser-based web services, in order to support large numbers of students- or other users. The reduced costs and reduced requirements of local space and maintenance, in addition of time allocation flexibility and accuracy approximations to hands-on experiments, all that represent the most powerful advantages and criteria of strength of remote laboratories over the previous mentioned categories of laboratories. In our remote lab, we focus on deploying various materials in order to have a hybrid laboratory with different resources, where we deploy physical materials for hands-on experimenting and other materials for remote experimenting, in addition of deploying virtualized and simulated practices of online experimenting. Moreover, we focus on developing and deploying resilient and flexible resources of software and hardware with various ranges of manipulation. These flexibility and resiliency are niched by providing the possibility of interconnecting between different circuits and components in various combinations, to experiment in the fields of electricity and electronics while having diverse experiments. One of the main aspects of research and development in the areas of remote experimenting is developing flexible hardware structures, where the possibility of interconnecting between diverse discrete components in different combinations. Moreover, manifesting high levels of flexibility and resiliency by providing the possibility of connecting any electrical or electronic component to any other component, while respecting the electrical limits of current and voltage to protect the hardware from failure and destruction. This paper presents the work of deploying different resources for remote experimenting on circuits structuring using VISIR (Virtual Instrument Systems In Reality) system and other materials such as NI Elvis and Quanser. The principal original work in this paper is the elaboration of a switching matrix architecture within VISIR system by developing an electronic board topology, to provide the physical possibility of connecting any electrical or electronic component to any other component on VISIR system, which provides more flexibility and more combinations of experiments on VISIR. In addition, this paper presents the work of developing an intelligent algorithm to control the flexible circuits structuring within the switching matrix architecture, while respecting the electrical limits of using the current and voltage during the online experiments on VISIR system. The elaborated switching matrix architecture enables to connect any electrical or electronic component to any other component on VISIR system, which provides more flexibility of remote experimenting by supporting more combinations of circuits. However, to exploit this switching matrix architecture and exploit its provided high level of flexibility, we had to develop an intelligent algorithm to be responsible of providing a dynamic control and monitoring on circuits structuring while respecting the electrical limits of current and voltage. This intelligent algorithm aims to exploit all the potentials of this switching matrix architecture and protect the hardware resources of VISIR system from destruction and failure. There are many relevant papers, which present different works of deploying [15], exploiting [16] or analyzing VISIR system [17], [18]. However, this paper is distinguished because it presents specific limits and potentials of using VISIR system to deploy online services of flexible remote experiments in electricity and electronics, where we present the limits and potentials of connecting the electrical and electronic components on VISIR's switching system. In addition, this paper is distinguished by presenting the technical solution of deploying a switching matrix architecture within VISIR system, where the possibility of connecting any component to any other component while using a proposed intelligent algorithm to have more flexibility of remote experimenting and to support more combinations of analog circuits. Without relying on the use of the proposed electronic board topology in this paper to deploy a switching matrix architecture within VISIR system, or relying on other potential solutions to deploy a switching matrix architecture, VISIR's switching system is physically unable to provide the possibility of connecting any component to any other placed component on its electronic breadboards (Section 3). Furthermore, VISIR system relies on the use of a limited static method to control and monitor the circuits building by using max files (files with max extensions), to describe predefined circuit structures to experiment on VISIR's switching system, which limits the number of supportable structures of circuits. The use of the max files by VISIR system limits the number of potential circuit combinations, because each max file is relied-on to describe and control the building of a specific predefined circuit. Therefore, we developed the intelligent algorithm (Section 5), to offer more flexibility and resiliency on VISIR system by supporting more combinations of circuits, which will enable the exploit of all physical potentials of VISIR's switching system and open the way to exploit all offered potentials of the developed electronic board topology. This paper is structured as follow: Section 2 presents the deployed projects and resources for e-learning and online experimenting in our remote laboratory. Section 3 presents the problematic of building a switching matrix architecture for circuits structuring. Section 4 presents the developed electronic board topology to provide the switching and multiplexing techniques to deploy a switching matrix architecture within VISIR system. Section 5 presents the developed intelligent algorithm for circuit's remote control and experiments monitoring on VISIR system. Finally, section 6 for conclusion.

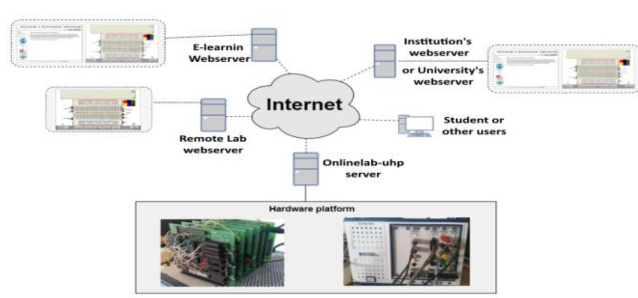


***Fig. 1**. Shared platform of hardware resources.*

2 Deployed Projects and Resources for E-learning and Online Experimenting in our Remote Lab

In our deployed remote laboratory, we integrate different resources and systems to manifest our principal subjects and perspectives of distance learning and online experimenting on analog circuits, digital circuits and different materials for remote experiments. In addition, we managed to adapt the deployed resources of software and hardware to satisfy two major axes of our research work. The first major axe of our research is deploying shared topologies of software and hardware for online experimenting to be accessed and exploited by different remote labs and educational establishments (Fig. 1), and the second axe is adapting usual materials and instruments of hands-on laboratories to online access and remote experimenting through the internet. From many other projects, web services and resources, we deployed VISIR system (Virtual Instrument Systems In Reality) for remote experimenting in electricity and electronic fields. We deployed the iLab architecture for simulated and emulated experiments while using LabVIEW resources. In addition, we deployed the Moodle platform for distance learning and online experimenting on simulated and virtualized practices in different educational fields. Furthermore, we adapted and deployed other products and resources of National Instruments (NI), NI Elvis and Quanser (Fig. 3), to be used and exploited through the internet; to conduct local and online experiments in electronic of energy.

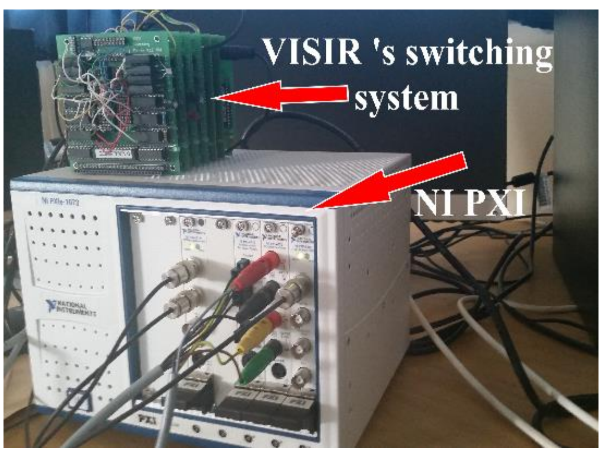


Fig. 2. Deployed system of VISIR in our remote lab.

Fig. 3. Deployed systems of NI Elvis and Quanser in our remote lab.

The VISIR system (Fig. 2) was created and developed in the Blekinge Institute of Technology [19]. Several other universities, remote laboratories and educational institutions around the world have deployed it, either for their own uses or for collaborative exploits through their own platforms of web-based services. VISIR system provides an online environment and platform for remote experimenting in electronics and electricity, where it serves similar classical functionalities and behaviours to the usual conducted activities of experimenting in hands-on laboratories, by supporting advanced levels of interaction and manipulation while controlling remoted instruments and materials. The iLab Shared Architecture (ISA) [20] has been developed at the Massachusetts Institute of Technology (MIT) in America. It has demonstrated that online laboratory's use and online experimenting environments can spread and scale to thousands of students dispersed on several countries around the world. Relying on this type of architectures and web-based platforms enables distant users to access remote laboratories through single sign-on interfaces while using simple administrative services through the internet; for twenty-four hours, 7 days a week. This iLab architecture is actually outdated and no longer supported by MIT. However, we are working on extracting its principal functionalities and services of exploiting LabVIEW resources, to be integrated and used through other e-learning platforms such as the Moodle.

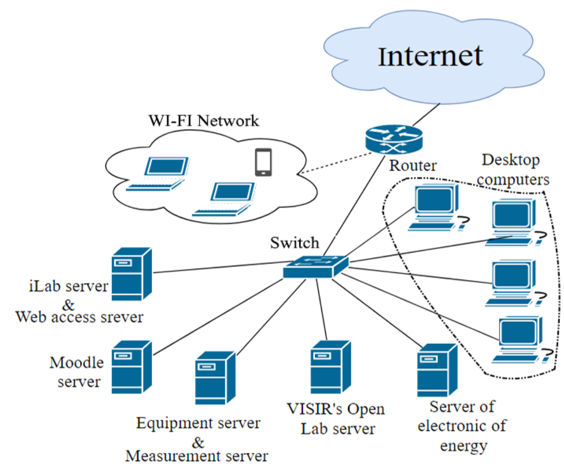


Fig. 4. Deployed services and network topology in our remote laboratory.

f the most known open-source platforms for e-learning and online experimenting on virtualized and simulated resources, such as by using Easy JavaScript Simulations (EJSS) [21] for online experimenting. The Moodle platform enables the creation of online web-based courses and quizzes, while providing the needed services of identification and authentication to ensure their online access only to subscribed and enrolled students [22]. This platform allows the communication, the exchange of information and the exchange of educational contents among geographically dispersed users of students and professors; either through web-based synchronous mechanisms such as chats or through asynchronous communication web services such as workshops and textual discussion forums. We are working on adapting our remote lab's services of distance learning and online experimenting to have an online and offline exploit, where the potential students, professors and instructors may use them with or without having access to the Internet. Nevertheless, the hardware aspect and used types of technologies limit the capacities of the offline service in term of covered geographical zones. Therefore, the current work of our research is about resolving this limitation by interconnecting Ethernet networks, Wi-Fi networks and WiMAX networks to provide the offline web services of remote labs at extendable scales of geographical territories. Even though, these extendable scales impose more security risks on deployed web resources and network architecture, which forces the conduction of further security tests on concerned technologies and resources [23]. In our remote lab, we deploy different web services of e-learning and online experimenting, as shown in Fig. 4, where we try to cover different fields of experiments while relying on smart management of environment and deploying embedded systems based on IoT (Internet of Things) [24]. In our remote laboratory, there is a deployed server used for the online access to our remote lab (Fig. 4), which aims to serve the essential tasks of presenting all services and activities of our deployed projects of e-learning and online experimenting. In addition, this web-based service of online access forwards the incoming online guests and students to all other web services and resources of our remote lab. On our remote lab's web services, there is the Open Lab platform of VISIR, which provides the principal services and functionalities of identification, authentication and scheduling to experiment in the practical fields of electricity and electronics on VISIR system. Moreover, it handles the support of the essential theoretical contents of served experiments in form of digital files, while supporting different assessment processes and interaction utilities between professors, students and instructors. On the web services of our remote laboratory, there is the web user application of VISIR system, which is deployed on the same server of the Open lab platform of VISIR in our remote lab. This web user application of VISIR is dedicated to be served through the internet as a web user interface, to experiment in the fields of electricity and electronics while using approximated shapes to the usual hands-on laboratory materials; such as oscilloscope, Dual-multimeter, functions generator, circuits breadboard, etc. There is the measurement server of VISIR system through our remote lab's web services, which is dedicated to order and manage the received online queries from online users; such as students, professors, instructors or visitors. It is in-charge of receiving the online queries through the internet, and then forwarding their content of commands and requests to the deployed equipment server of VISIR system; to apply the requested parameters changing and execute the measurements of experiments. There is VISIR's equipment server through our remote lab's web services, which is in-charge of the control and monitoring of the deployed materials of VISIR system. The equipment server of VISIR system is responsible of the next functionalities: applying the online commands and requests of received packets from the measurement server, conducting the requested measurements at any point of built circuits, and then forwarding the collected results to the measurement server in order to be provided to the end-users of online experimenters. Through our remote lab's web services, there is a service of remoted experiments in electronic of energy, which aims to control and monitor two embedded systems: NI Elvis and Quanser (Fig. 3). We adapted the systems of NI Elvis and Quanser from local exploit to the online experimenting in electronic of energy through the internet, in order to support higher number of experimenters on these two systems.

3 The Concept of Building Switching Matrix Architecture for Remote Circuits Structuring

The deployed switching system of VISIR in our remote laboratory is an electronic system for the control of electrical and electronic components, and for circuits structuring while using those components. It contains multiplicity of square electronic boards mounted and arranged in a parallel extendible architecture. VISIR's switching system uses two different bands of parallel branches of copper to communicate and interconnect between its integrated electronic boards. The first band of parallel branches is dedicated to circulate and communicate the control data, and the second band of parallel branches is for the transfer of electrical signal between the electronic boards of VISIR system. To elevate the potential number of placed-on components on VISIR's switching system for experimenting, we must add more electronic breadboard cards, also referred as component cards (Fig. 5), to the switching system in a parallel extending. Furthermore, to augment the number of supportable components or the possible wiring interconnections between components, we must add more breadboard cards on VISIR's switching system; because each one of these breadboard cards (Fig. 5) supports the use and control of only ten components, or ten shortcut wires, as a maximum. To establish a physical connection of wiring between two different components on VISIR system, they must be leaded and wired to the same wiring node (Fig. 5) on the switching system of VISIR. To interconnect between two different components placed on the same components card (or breadboard card); two physical wires must be used to lead the ends of these components and connect them to the same named wiring node. Otherwise, these two components must be wired to two wiring nodes with the same name (Fig. 5); in case where the two of them are placed on different cards. Alternatively, we must rely on the use of a shortcut wire to establish the physical connection between any two components wired to two different wiring nodes with different names on VISIR's switching system. On VISIR's component breadboards, a shortcut wire (Fig. 5) is a physical wire placed on a component node to interconnect between two physical components connected to two different wiring nodes. In a stricter manner to reframe the use of shortcut wires on VISIR system; each one of these shortcut wires will offer the possibility of circulating the electrical signal between two electronic or electrical components related to different named wiring nodes on the breadboard cards of VISIR's switching system. If two components placed on VISIR's switching system without having a physical wire connection to the same named wiring node, and do not have shortcut wires to interconnect between them in case of not being related to the same wiring node; VISIR's switching system can do nothing to physically connect them and circulate the electrical signal between them. Therefore, VISIR's switching system is not properly said or referred as a switching matrix system; because it is physically limited and unable to connect any of its placed-on components to any other components of them, which a switching matrix structure should be able to do (Fig. 6).

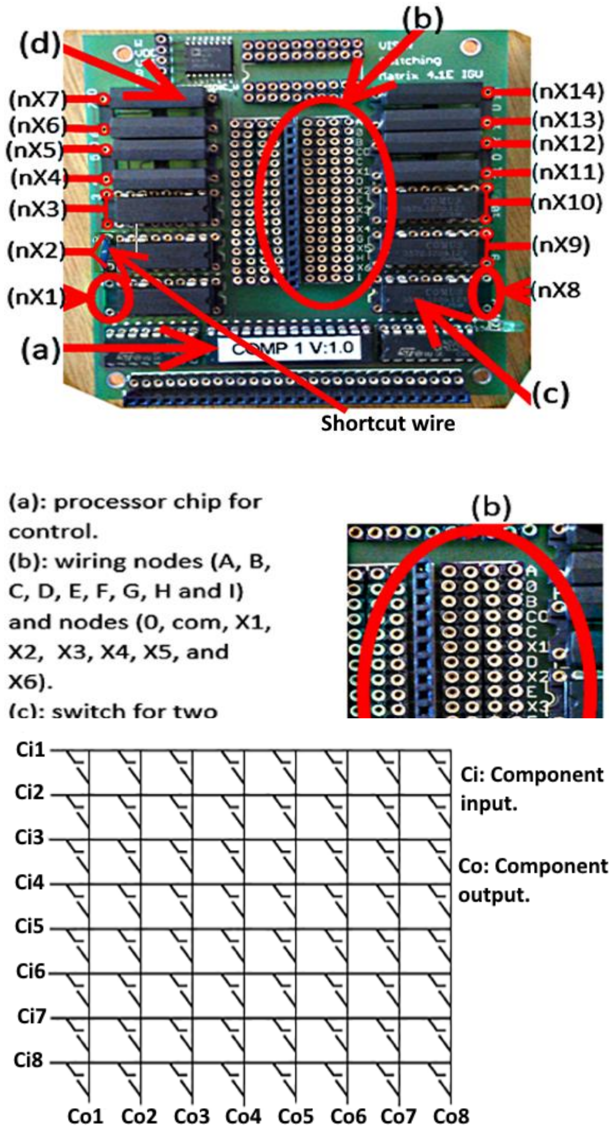


Fig. 6. *Switching matrix architecture to connect any electrical or electronic component to any other component*

Instead of having the mechanisms of a switching matrix architecture (Fig. 6), VISIR's switching system offers a direct linear switching control on each component node, to decide and monitor the use of its placed-on component in any potential circuit. Therefore, to interconnect between two different components on VISIR's switching system, they must be leaded using physical wires as previously described.

In another manner to reframe the previously described limitation of hardware on VISIR, there is an absolute necessity to have physical wiring connections between the used components in any potential circuit, direct wiring connection or indirect connection using shortcut wires; otherwise, VISIR's switching system will not be capable to circulate the electrical signal between these components. Therefore, this confronted limitation obligates a wasting use of more component nodes, to place the needed shortcut wires or to place an over redundancy of electrical and electronic components, in order to augment the number of supportable wiring connections and possible combinations between components. These leveraging techniques of using shortcut wires and relying on components redundancy introduce an overuse of more component boards on VISIR's switching system, which means more monetary cost. VISIR's switching system offers the technical methodology of circuits building and measurements conducting on predefined electrical and electronic circuits or their subcircuits. In addition, VISIR's switching system offers the possibility of reusing the same component of a circuit in other circuit structures, in condition of having direct wiring connection of physical wires or having indirect connection using shortcut wires; as previously described. These offered technical methodologies of circuits building and structuring are handled by using files with "max" extensions (max files) for each supported experiment. These max files are used for each predefined circuit, to define and describe the allowed components and their interconnections by determining the component nodes and the wiring nodes of each component. In addition, these max files are used to set the electrical conditions and limits of use for each supported experiment, by determining the maximum values of current and voltage and defining the type of power supply: Direct Current supply (DC) or Alternating Current Supply (AC). The offered techniques of using max files and physical switches on VISIR's switching system assure the physical and technical security of VISIR's placed-on components and its used materials of hardware. Nevertheless, in addition of the already mentioned and described physical limitation of VISIR's switching system, which limits the possible interconnections between components, the use of the max files presents more logical barriers and limitation of possible combinations between the placed components on VISIR's switching system; and this time at the level of software. Relying on the use of a programmable intelligent algorithm [25], [26] within VISIR system, to control and verify the interconnections between components and decide if it is secure to use them in any requested circuit and execute the measurements on them, is more suitable to have more possible circuit combinations and to have more logical flexibility. Therefore, we developed an algorithm for decision processing (Section 5), to monitor and secure the circuits building on VISIR's switching system; in order to have more resiliency of experimenting and more combinations of circuits. We developed an electronic board topology (Fig. 7) to deploy a switching matrix architecture within VISIR's switching system (Section 4), where the physical possibility of connecting any electrical or electronic component to any other component. However, relying on the use of the max files will limit the exploit of the potentials of the switching matrix architecture, because the max files are used to control the experiments on VISIR system according to predefined circuit combinations; as previously described. Therefore, the presented algorithm in section 5 is essential to exploit the potentials of the switching matrix architecture and to support more flexibility of experimenting on VISIR system. The presented electronic board in section 4 and the presented algorithm in section 5 aim to deploy a switching matrix architecture within VISIR system, where the possibility of connecting any component to any other component while respecting the electrical conditions and limits of use in term of current and voltage. As a result, online experimenters on VISIR system will have more possible circuit combinations and more flexibility of experimenting.

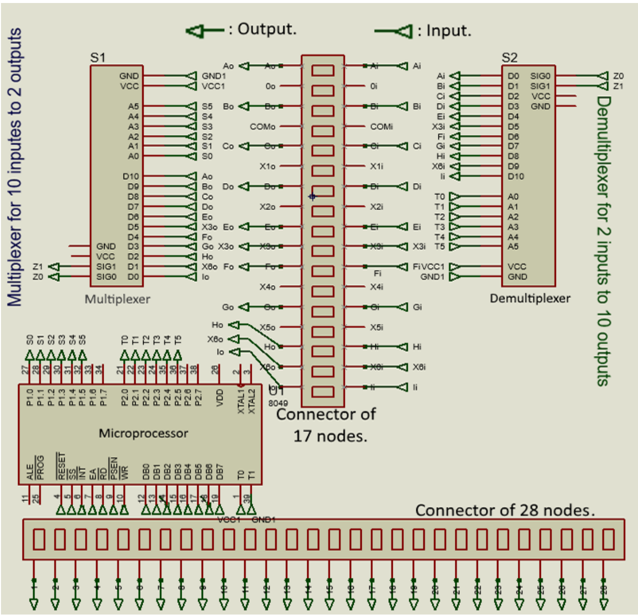


Fig. 7. *Developed electronic board topology to elaborate a switching matrix architecture for circuits building within VISIR's switching system*

4 Developed Topology of Proposed Electronic Board to Deploy a Switching Matrix Architecture within VISIR System

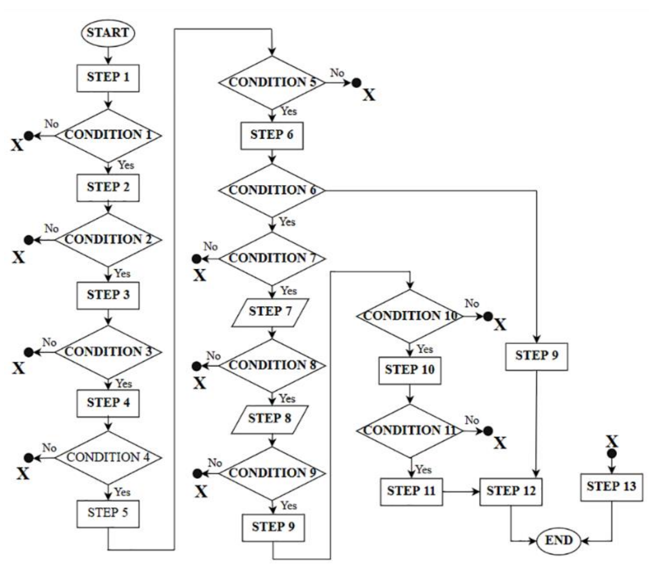
Since VISIR's switching system does not support the physical possibility to connect any electrical or electronic component to any other component; we developed an electronic board topology to provide the needed techniques of switching and multiplexing, to manifest a switching matrix architecture (Fig. 6) for analog circuits building within VISIR's switching system. The developed electronic board topology in Fig. 7 consists of the next elements:

- Connector of 17 nodes, which is used to support the copper branches band to circulate the electrical signals between VISIR's electronic boards.
- Connector of 28 nodes, which is used to support the copper branches band to communicate the control data between VISIR's electronic boards.
- Multiplexer, which is used to select two signals of two wiring nodes at its inputs and forward them to its outputs.
- Demultiplexer, which is used to forward two signals at its inputs to two selected wiring nodes at its outputs.
- Microprocessor, which is used to process the received data at the level of the copper branches band of data communication, and control the use of integrated multiplexer and demultiplexer.

As previously described in section 3, VISIR system supports only the building of predefined circuits, or their subcircuits, from scratch while using direct connections of physical wires to the same wiring nodes or using indirect wiring connections of shortcut wires. Therefore, this developed electronic board topology will be responsible of interconnecting between any two components that do not have neither direct connections nor indirect connections to each other on VISIR's switching system. As a result, this electronic board topology opens the way to, physically; connect any end of an electrical or electronic component to any other end of a different component on VISIR system. This developed electronic board topology is offering the multiplexing and switching techniques to provide the possibility of interconnecting between any two wiring nodes on VISIR's switching system. Thereby, we will be able to interconnect between any two components on VISIR system, even if there are no wiring connections between those components on VISIR's switching system; as previously described in section 3. The conditioning of the circuits building on VISIR system, at the level of electrical and electronic limits of use, will be logically supported by using the developed intelligent algorithm in Fig. 8 (section 5); to offer more resiliency and flexibility of experimenting by supporting more combinations between the placed components on VISIR's switching system. This electronic board topology is developed to manifest a switching matrix architecture within VISIR's switching system, which offers more potential combinations of circuits and more experiments to conduct. This electronic board topology is developed also to reduce the monetary cost of adding more breadboard cards on VISIR's switching system which are used to support more components redundancy or more shortcut wires.

5 Developed Intelligent Algorithm for Remote Control on Circuits Building

We developed an intelligent algorithm (Fig. 8) to control and monitor the remote building of circuits on VISIR system, as an alternative of using the max files; to monitor the circuits building and measurements conducting of each potential experiment on VISIR's switching system [25], [26]. This developed algorithm is logically based on decision handling to have a smart machine control [27] on VISIR system. This algorithm offers more resiliency and flexibility to establish the physical interconnections between electrical and electronic components on VISIR's switching system, instead of relying on the max files. These max files present a limited static method where there is only the possibility of building predefined structures of circuits, or build portions of those structures as subcircuits. Therefore, this intelligent algorithm is developed to surpass the limitation of using max files by providing more flexibility and freedom of circuits structuring on VISIR's switching system while respecting the electrical limits of current and voltage.



This developed intelligent algorithm (Fig. 8) offers a dynamic method of control and monitoring during components interconnecting and circuits building on VISIR system, while respecting the electrical and electronic limits such as the maximum values of voltage and current, in addition of controlling the supportable power supplies and measurements execution. This presented algorithm in Fig. 8 is intelligent because it is based on a wide interval of decision making while relying on numerous processes of calculation [25], [26]. It relies on organized steps to control and test the requested components and circuits for experimenting before supplying them with any source of power, to avoid any electrical risks. In addition, this algorithm is based on a structured logic [27] of components interconnecting where, as an example, each output of a component should not be connected to the input of the same component; neither directly nor indirectly. Furthermore, this algorithm is based on respecting the limits of maximum supportable values of current and voltage. Generally, it will be more convenience to combine the use of this algorithm with the use of the max files of VISIR system, to provide a more controlled environment of experimenting and reduce the amount of calculations when having more composed circuits, in order to open the way to serve high numbers of online experimenters on VISIR's switching system. Instead of integrating learning processes within this developed algorithm, we rely on the repeated logic and patterns of reasonable conditioning on circuits building, to avoid consuming more storage space for the data of circuits building and their potential structures. Moreover, this algorithm is developed to exploit all the potentials of the physical switching matrix structure (Fig. 6), where the possibility of connecting any electrical or electronic component to any other component placed on VISIR's switching system. This proposed algorithm is based on multiple steps and conditions of use. The executed step processes (presented STEPS in Fig. 8) of this algorithm are as follow:

1) Defining all used components in the requested circuit.
2) Determining each two ends connection between the components of requested circuit.
3) Defining the entries and the ends of the circuit.
4) Determining the output of each component and its successive component.
5) Determining the output of each component and its successive series of circuits.
6) Determining the used power source.
7) Determining the voltage values between the inputs and outputs of components.
8) Calculating the value of electrical current, which is going to be absorbed by the circuit.
9) Building the circuit without power supplying.
10) Testing the ends of built circuit to avoid electrical risks.
11) Power supplying the built circuit.
12) Executing the requested measurements on the built circuit.
13) Rejecting the experiment execution.

The transitional conditions of this algorithm (presented CONDITIONS in Fig. 8) are as follow:

1) Verifying that all used components of requested circuit are actually placed on VISIR's switching system.
2) Verifying that each requested connection between two ends of two components is actually supported on VISIR's switching system.
3) Validating that if the entries of a circuit are connected to a power source, then the ends of that circuit should be connected to the ground.
4) Verifying that the output of each component is not directly connected to the input of the same component.
5) Verifying that the output of each component is not indirectly connected or leaded to the input of the same component.
6) Verifying whether the circuit is actually relying on the use of certain power source, or is it not relying on any source of power?
7) Verifying whether the requested power source for experimenting is physically supported for the requested circuit, or is it not supported for that specific circuit?
8) Verifying that the used voltage value of validated power source is less than the maximum supportable voltage.
9) Verifying that the absorbed value of electrical current from the validated power source is going to be less than the maximum supportable current.
10) If all conditions are validated, then accepting the building of the circuit without power supplying.
11) Testing the ends of built circuit to determine whether they are secure to be power supplied without electrical risks, or are they at risk to be damaged?

Remote experiments in educational fields and engineering areas are increasingly being integrated and relied-on [28], [29], where the flexibility of experiments conduction is a major axe of concern. Therefore, in this paper, we present the work of developing a switching matrix architecture, which relies on an intelligent algorithm, to have more flexibility of remote experiments in term of components interconnecting, circuits structuring and resiliency of experiments conditioning while exploiting VISIR system through the internet.

6 CONCLUSION

There are different factors that determine how much any service of distance learning and online experimenting will be successful; among many other factors, there are the resiliency and diversity of provided contents and services, in addition of the continuous availability and reliability of deployed systems of hardware and software. The presented electronic board topology in this paper is developed to deploy a switching matrix architecture within VISIR's switching system, which helps to support the physical interconnection between any two ends of different components on VISIR's switching system. Therefore, this developed electronic board opens the way to support more combinations of analog circuits on VISIR system. The proposed switching matrix architecture in this paper aims to provide more flexibility and resiliency of experimenting on VISIR system, by supporting the interconnection between any two components placed on VISIR's switching system while exploiting more potentials of VISIR's hardware for e-learning purposes. Therefore, the presented electronic board and presented intelligent algorithm in this paper enable the deployment of a resilient architecture within VISIR system, where the support of more circuit combinations and more possible diversity of experiments through the internet while respecting the electrical limits of current and voltage.

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