DESIGN AND CONSTRUCTION OF TEACHING MODULES FOR VIRTUAL LABORATORY OF INDUSTRIAL INSTRUMENTATION, RACE ENGINEERING IN ELECTRICAL MAINTENANCE

Altamirano Pinchao Edgar Polibio
Méndez Caicedo Paul David
Engineering in Electrical Maintenance
Universidad Técnica del Norte, Av. 17 de Julio 5-21 Ibarra
ealtamirano@emelnorte.com---pmendez@emelnorte.com

Summary: This research paper details the design and implementation of test modules for materials Automatic Control, Electronic Instrumentation and Industrial Instrumentation, for which the various common electrical and electronic elements, found in the industry was investigated and its different applications, with appropriate classification in terms of technical and electronic requirements.

The research is based on performing five chapters, the first being the problem of research, development and definition of the problem, objectives was also raised; a general and four specific who led the research problem. It followed the theoretical framework was made obtaining main topics and subtopics as; control systems, software and hardware elements In the development of the research methodology was used, inductive and deductive method and techniques and instruments LabVIEW and Altium Designer software was used. In chapter four is the development of technological proposal, where the actions are to implement the training modules with the aim of facilitating learning and use of the modules after previous research for the design, Finally conclusions are drawn and recommendations of this research

1. INTRODUCTION

Initially, when there were elements for automation or control of a process, people contrived to make industrial techniques in order to obtain optimum results from a process, then the first mechanisms that moved through emerge hydraulic devices, such as pulleys and levers, but not long when perfecting the mechanics allowed to build complex automata, to the development of precision mechanics required for different industrial processes

In recent times, technology has solved major industrial problems at the time would be impossible to solve, factors such as time reduction in certain tasks, improvement of work, cost reduction processes, partial or global automation, among others, have It has been the benefits of support provided by the software from mathematical calculation, accounting, automation, measurements and simulations, all these advantages have become a powerful ally for both private companies, industries, professionals and without hesitation for students, being a tool effective for solving problems and developing new ideas.

1.1. Problem Statement

The need to implement training modules for the virtual laboratory of Engineering in Electrical Maintenance, is because the materials automatic control and industrial instrumentation, need training modules, which will help improve the theory by developing practices

The subjects of Control and Industrial Instrumentation are important because they contribute to the improvement of industrial automation processes, and in the absence of a virtual laboratory to develop practices that these materials require, in order to improve theoretical contribution to the practical, so that implementing the teaching modules, supports the development of students as they include sensors and actuators, this represents that students are in the ability to perform testing, maintenance, changes and simulations in different electrical machines or perform partial or total control in the industry with the help of new technologies.

1.2 Objective

1.2.1 General objective

Design and build teaching modules, materials for industrial instrumentation and automatic control in the laboratory of Engineering in Electrical Maintenance, in order to improve the skills of students.

1.2.2 Specific Objectives

• Investigate educational applications of electrical and electronic equipment, installed in the test modules .
• Check the behavior of electronic elements, their characteristics and their effectiveness.
• Implement the knowledge of programming languages that handles graphics control modules.

1.3 Justification

The construction of the teaching modules in which the use and manipulation of elements of solid state shown, is intended to enable students to develop small research projects, and have full knowledge of the systems used by electrical, electronic engineers, because it is ideal for any measurement or control system, in order to achieve competitive levels of knowledge and improve their professional profile.
This research project helps improve student understanding through the implementation of training modules in the virtual laboratory, because in modules include temperature sensors, speed, position, standard actuators such as heaters, motors, LED indicators, plus the acquisition of analog voltage signals, digital signals on / off and pulsatile signals and relay drive type

2. DESIGN PROCEDURE

There are a variety of development environments used in teaching control systems. The problem lies in finding a system that fits in a good way with the program of theoretical studies - Practical Matters Instrumentation and Automatic Control Engineering in Electrical Maintenance at the Technical University of the North.

The requirements for professionals in technical sciences are becoming more demanding, due to the rapid development of science and technology. For this reason it is necessary to orient teaching in new ways that facilitate learning and management control systems that can adapt quickly to technological developments and allow imparting knowledge in stages and safe.

It is stated that the teaching modules for teaching technique adapted to the requirements for learning in the field of control systems. Why its design is imperative to carefully select its elements, to fulfill the objectives in each practice.

2.1. Purpose

Implement training modules based on a set of simple elements that represent typical cases of industrial systems Laboratory Industrial Instrumentation and Automatic Control in Engineering in Electrical Maintenance based on an acquisition card DAQ USB 6001 data and design a and practical use that can be made in these modules manual..

2.2. Temperature circuit design

2.2.1. Burner

For its speed and direction of the most appropriate heat for coaches are halogen lamps. The other elements can burn the module and endanger the wearer

FIGURE NO. 1 halogen lamp

2.2.2. Temperature sensor

EPC for the most appropriate is the LM35 by having better linearity, faster and good temperature range to measure the heat generated by the halogen lamp

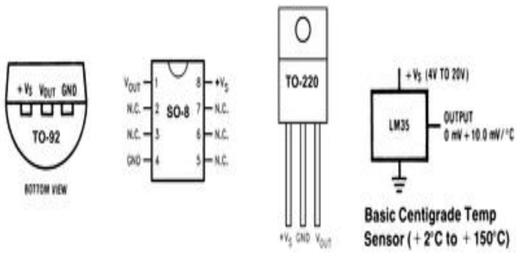

FIGURE NO. Sensor LM35 integrated 2 Source: (Donald, 2010

2.2.3. Circuit design with elements in the teaching modules

Because the lamp is energized to 110Vac, you need to implement a power circuit. This circuit is an ace voltage control by triggering a TRIAC, with the help of an opt coupler, for which the instruments recommended by the National circuit, detailed in the following illustration is used.

To determine the resistance of the lamp using Ohm's law:

$R=V^2/P= (110V^2)/50W=242\ \Omega$

The RMS maximum current passing through the lamp is given by alpha equal to zero, ie all voltage 110V.

$I\_rms=V\_rms/R=110V/242\Omega=454\ mA$

The maximum rms current passing through the triac will be

$I\_triac=I\_rms/\sqrt{2}=454mA/\sqrt{2}=321\ mA$

Is complex find a triac with these values, found in the market is the triac BTA 12 600 volts and 12 amps rms current

2.2.4. Calculation for the control circuit

Due to the voltage difference an opto triac is used MOC 3020. For LED diode resistance R is calculated as follows:

$R=(Vcc-V\_LED)/I\_LED=(5V-1.7V)/10mA=1000\Omega$

For the R1 resistance led diode opt coupler

$R1=(Vcc-V\_LED)/I\_LED=(5V-2.1V)/13mA=223\Omega$

The selected opt coupler, is recommended to apply a normal voltage 30V and a current of 9mA.

$R2=V\ opto/I\ opto =30V/9mA=3.3\ k\Omega$

R3 is calculated for the voltage divider

$V\ opto=(Vac\times R2)/(R3+R2)$
$30=(110\times 3.3k)/(R3+3.3k)$
$R3 = 10k\Omega$

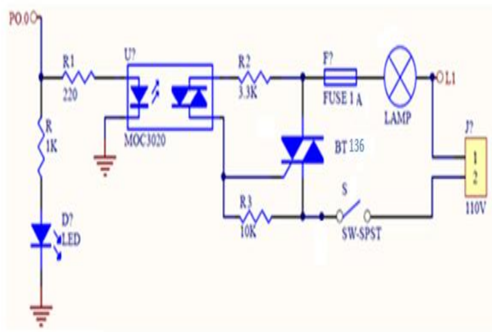

FIGURE NO. 3 and power control circuit implemented

2.2.5. Sensor LM35

Because the sensor output voltage is high, it is not necessary to implement a conditioning circuit, which is why the sensor is energized and connects directly to an analog input card data acquisition. MALONEY, Timothy. J (2009)

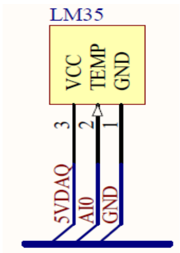

FIGURE No.4 LM35 temperature sensor. Source: (Cogdell, 2002)

The calculation of voltage resolution and the division of the output voltage to the voltage resolution to identify the values that have variable temperature control program.

$$Resolución = \frac{Vmax}{2^n} = \frac{20V}{2^{14}} = \frac{20V}{16384} = 0.0012V$$

2.3. DC Motor Circuit

As an element of high current is required to implement a circuit to raise the current to have a good engine speed control. The following circuit consists of an operational amplifier in follower configuration, U1 and U2 LM358 to ensure impedance matching and avoid brownouts, followed by a gain amplifier 1 to maintain stable voltage. The circuit is energized by an analog output of the DAQ. DORF, Richard. (2005),

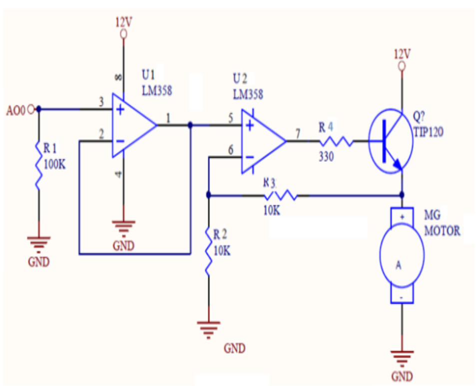

FIGURE NO. 5 Circuit for DC Motor

2.3.1. Encoder

The encoder to be an opt digital type electric element does not need a preconditioning since the output of this element can be connected directly to a digital input or counter input of the data acquisition card type

.

For resistor R5 LED diode transistor opto

R5=(Vcc-V_LED)/I_LED =(5V-2.1V)/13mA=223 Ω

The resistance is a resistance R6 of protection which should be of a very high value, it is advisable to 100K ohm.

To check the operation of the encoder an indicator circuit, which in turn stabilizes the sensor signal U to enter it to the DAQ, using a Smith trigger Triger 74LS14 used. Resistor R7 LED diode is calculated as follows:

R=(Vcc-V_LED)/I_LED=(5V-1.7V)/10mA=1000 Ω

2.3.2 Stepper motor

To control the stepper motor the ULN2803 driver, which is a circuit where transistors so willing to let you enable and disable the motor windings M1 to M4 are grouped according to the pulse sequence is used, which is sent from the digital lines P0.1 to P04 card data acquisition.

In addition to checking the operation of Driver is available 4 leds, type bar, to show that the signals output from the DAQ, reach the engine

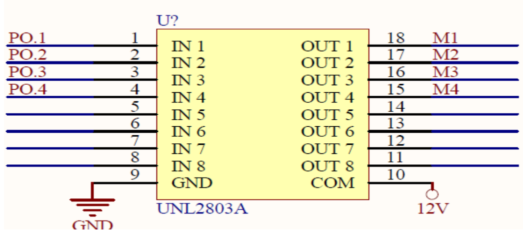

FIGURE NO. 6 Driver for stepper motor SOURCE: FLOYD L. Thomas. (2008),

2.4. General Purpose Relay

The circuit used for the relay is similar to that used for activation of the lamp. the relay terminals (NC, COM, NO) is left free for the user to connect any type of electric actuator, with the purpose of experience and creativity is encouraged

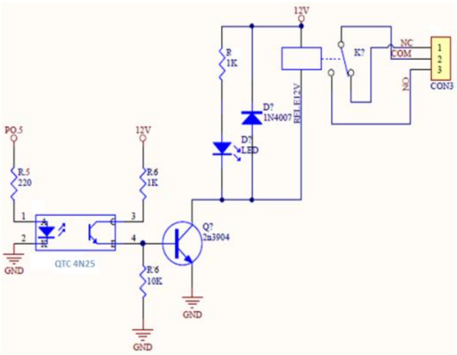

FIGURE NO. 7 circuit for driving the relay

2.5. Button

In order to have a safety means has decided to equip the PEC a button that serves as an emergency stop to disconnect entire module if there is a drawback and thus avoid damage to the elements of the coach. The implemented circuit is detailed below.

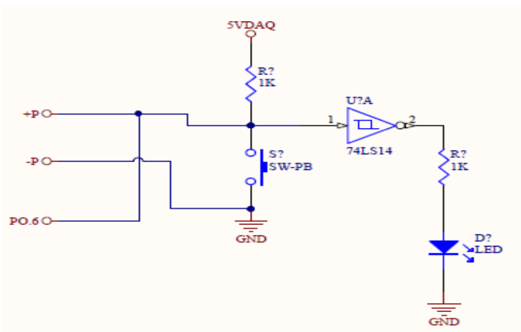

FIGURE Nº.8 circuit for the emergency button

2.6. Voltage and current measurement

For the beginner student can make a data acquisition simply, is arranged modules two knobs, one voltage and one current, which can vary these electrical parameters and register in LabVIEW. For measurement of voltage feedback, there is provided a potentiometer as voltage divider and current potentiometer connected to a transistor for regulating the base current is used thus changing the current flowing between the + I -I ranging connected to the input of the data acquisition card

Implementation of training modules

Once designed the wiring diagrams for modules a list of components is performed. To make the schematic and PCB tracks, the Altium Designer software, which is a specialist for these projects program, which has incorporated several major libraries used electronic devices.

Elemento	PERIFÉRICOS DAQ			
	Salidas Digitales	Entrada Análoga	Salida Análoga	Entrada Contador
Lámpara	P0.0			
Motor PAP	P0.1			
Motor PAP	P0.2			
Motor PAP	P0.3			
Motor PAP	P0.4			
Relé	P0.5			
Pulsador	P0.6			
LM 35		AI.0		
Entrada Voltaje		AI.1		
Motor DC			AO.0	
Sensor DC				PFI.0
Sensor PAP				PFI.1

TABLE NO. 1 peripherals connected to the DAQ

2.6.1. Schematic design

To prepare the schematic diagram a new project is created, on the File >> New menu, where you have a list of file types that can be created. Shematic Document, which generates a file extension * .sch is chosen. In this file, the circuit you want to pass the PCB is drawn.

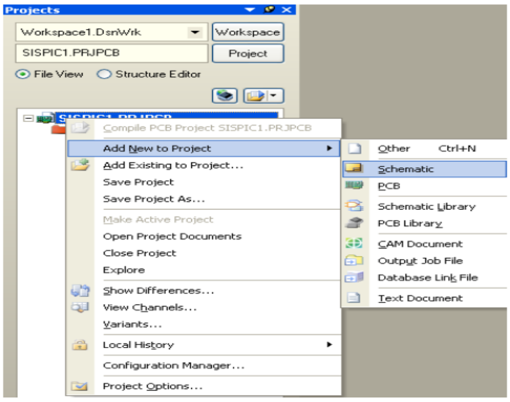

FIGURE. 9 New Schematic in Altium

The libraries that are to be used is loaded. When the schematic is opened, there are two parts on the screen: one on the right where the circuit, and another to the left, where you have the tabs: Browse Explorer and Sch. In this last tab is selected bookstores Browse and Add / Remove choose to add or remove libraries.

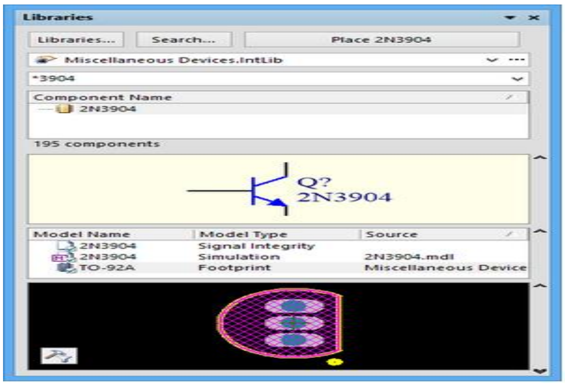

FIGURA Nº.10 Librerias de componentes

If it is not the component you need, the Find command that is down to the left is used. With this feature, looking all components Protel that name in any bookstore. Is then only necessary to load the appropriate library.

Most components such as resistors or capacitors, are in Miscellaneous, which is the library that is loaded by default. Once loaded the libraries that are to be used, it is passed to the creation of the schematic itself.

On the left side of the screen, a list of components containing the library you choose appears. To create the circuit, it is only necessary to select a component and placing it on the grid of the schematic. As you placed the desired component, you have to clicear twice about it and a picture called Part where there are four tabs appear: Attributes, Graphical Attrs, Part Fields, Read-Only Fields

For this diagram only the first tab is displayed by default is used. In this tab, there are several options that will only use the following.

2.6.2 **Creating a PCB**

Before considering whether the schematic done is correct, the plate to be inserted where the components are created. In this case, the "wizard" PCB is used. To do so runs the Printed Circuit Board Wizard found in the Wizards tab when a new project is created; in this case the option Custom Made Board whose units are metric is used.

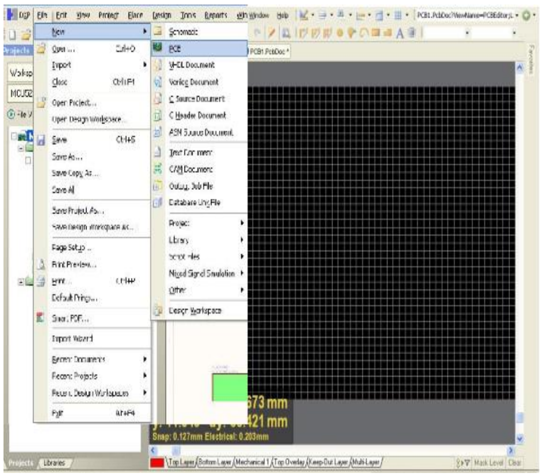

FIGURE NO. 11 Printed Circuit Board

On the second screen, a series of options to define the different lengths: the dimensions of the rectangle, the width of the track, etc. Also in the bottom of the screen there are a number of options that are used for complex designs, so they are disabled.

On the third screen, a picture of what will be the shape of the plate and what their size appears.

The next two screens are left as they are. However, in the sixth screen should indicate the type of welding to be done: either surface or inserted. For this project is chosen insert the components, so Trough-hole Components is selected. She also asked how many ways there is to be between pins. For this case is chosen, ie One Track selected.

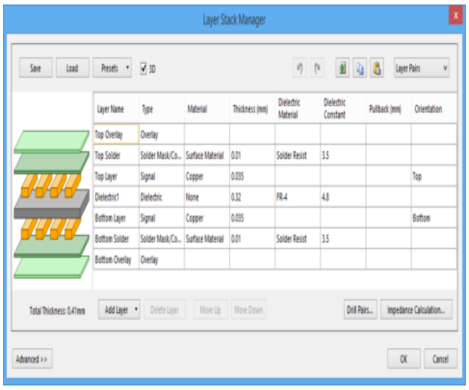

FIGURE NO. 12 Types of plate and capable

In the seventh screen, question the dimensions of the tracks, pin holes, and the distance between tracks. Commonly default parameters allowed. Most likely then, once placed and routed components, forced to change these lengths, but that can be done later.

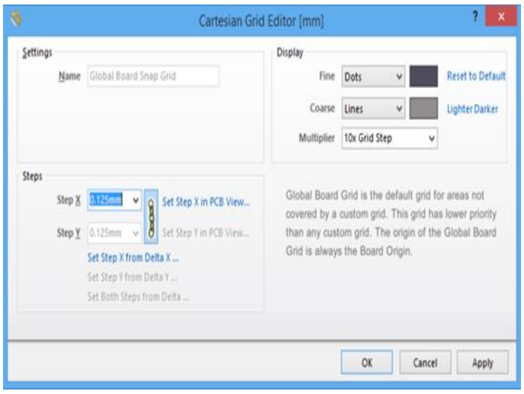

FIGURE NO. 13 Grilla PCB

Component placement

After checked and executed the PCB Update will appear in the fichero.pcb that all components have schematic, but ordered online will appear next to the plate. Protel option to place components on the PCB according to the size of the components is then used.

To do this, the Auto Placement Tools menu option is used and then select Cluster Placer and we have a possible placement.

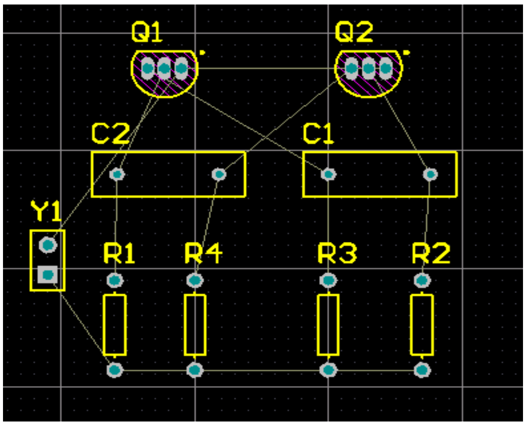

FIGURE NO. 14 Manual location elements

The common problem is that Protel has too board components and therefore also gather clues too. So it is advisable to place "by hand" all components. Thus, the components may be split into sets each perform a specific function.

2.6.2. Routed

The routing, once placed all components is done automatically. To do this, the Auto Route menu, the Route All option is used. It may happen that due to route more than once due to problems with the thickness of the tracks, the separation between the two, etc.

To change the thickness of the lines to a new location or, in the Design menu, select Rules. In this option, you have all the rules used Protel for routing. With these rules defined, it is rerouted and if the plate is obtained is not adequate, the properties are changed again. And so until the desired plate is obtained.

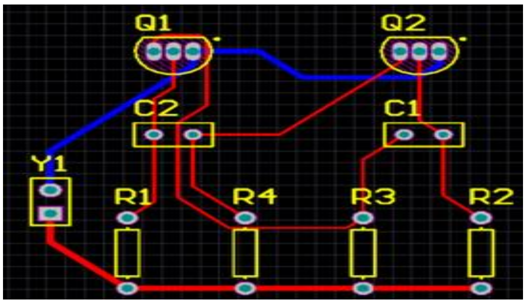

FIGURE NO. 15 routing of control elements

2.6.3. **Print**

Finished the whole process of the construction of the PCB, continue with printing the circuit. To perform this step, a new PCB Printer file whose extension is * .ppc is created. In this file, it plays the PCB with tracks of the upper and lower face and components. What you should get are two slides with holes and tracks all.

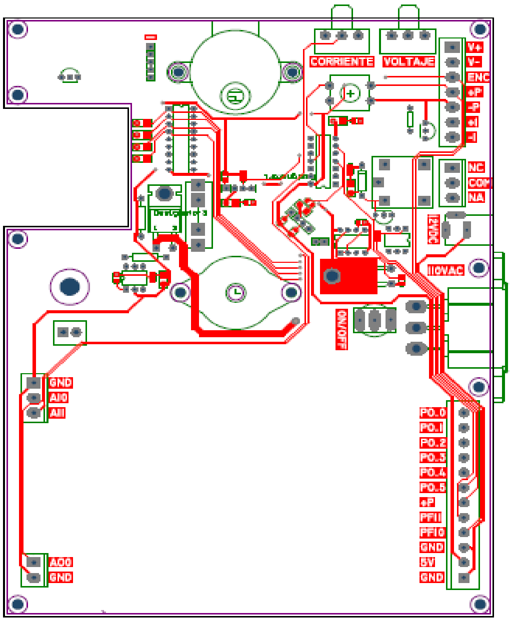

FIGURE NO. 16 PCB module front.

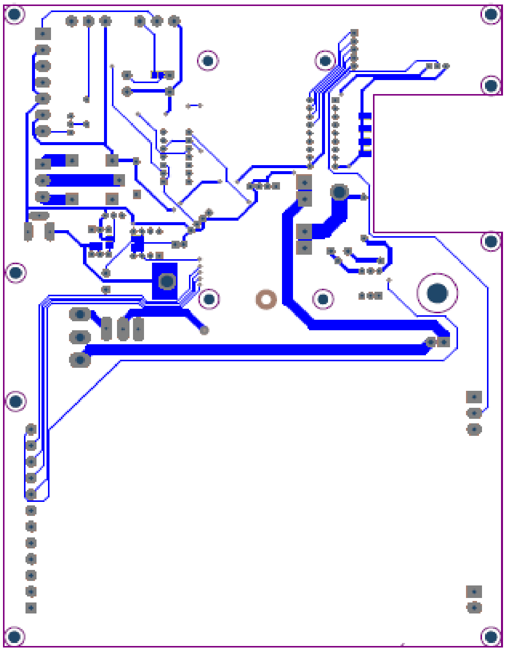
FIGURE NO. 17 PCB module backside

You need to create new designs for printing for it, on the left side of the screen, right-click it and select Insert Printout. a picture called then appears Printout Properties. In this way the PCB is generated and is finally welding work and checking that everything is correct analysis of performance.

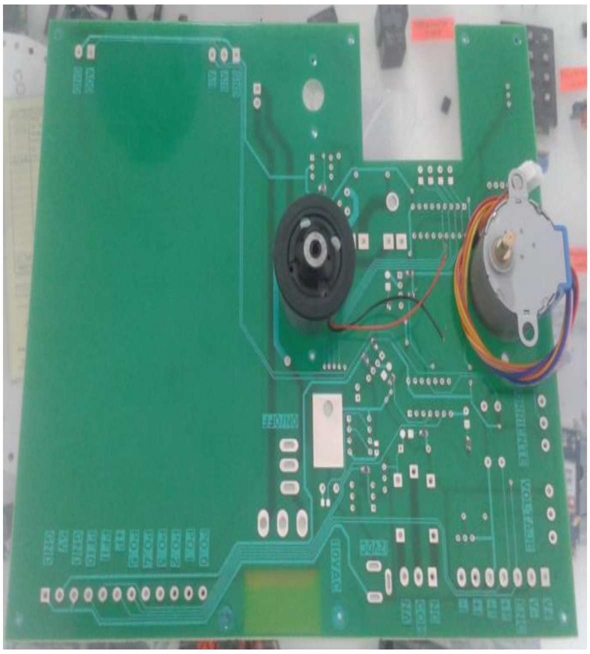
FIGURE NO. 18 modules under construction

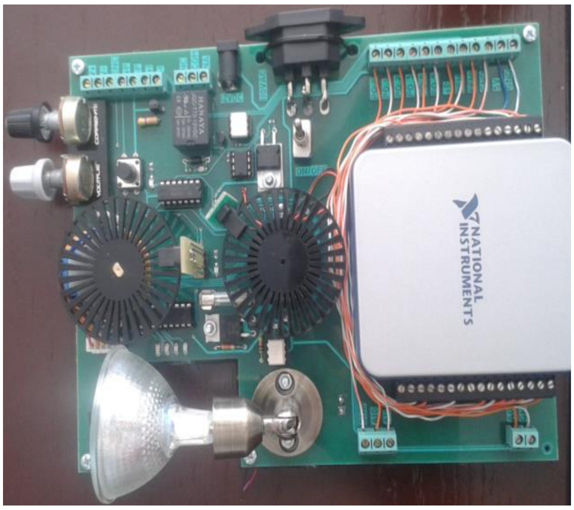

FIGURE Nº.19 teaching modules – end

2.6.4. Test and results

After developing the teaching modules, several tests are performed to verify that function properly all its components. The tests focused on confirming: if there is miscommunication PC - DAQ, reviewing peripheral card data acquisition, proper operation of all actuators, controllers, sensors and measuring voltage and current.

3. conclusions and recommendations

3.1. CONCLUSIONS

With the theoretical investigation it found that there are many types of sensors, actuators and controllers, a variety that allowed for simple modules that allow both teachers and students to identify and verify the operation of the elements that are common to industrial level.

With the teaching modules, you can implement industrial applications, such as the temperature sensor, which is performed by LM35. This application can be replicated in the industry where the temperature sensor LM35, can be decisive in the safety of people working in industry or in the implementation process, because with this it prevents the person is exposed to high temperatures, to avoid that raw material or a product result of several damaging process.

The built modules constitute a major contribution to the laboratory of the race because they allow the teacher to conduct a comprehensive training to their students corresponding to operation of automatic control, electronic instrumentation and virtual instrumentation.

3.2. Recommendations

- Students are encouraged to investigate methods of implementation of PID controllers for development in the PEC and further discussion to promote research.
- Using data acquisition cards to operate other teaching modules so that students can experience what it is the full development of electronic circuits for control of real systems.
- Encourage the student to perform alone other programs that do the control and monitoring of two or more modules in a computer network for the purpose of the ways to implement control networks and systems more complex automation are studied.

4. REFERENCES

DORF, Richard. (2005), Modern Control Systems. Tenth Edition. Pearson Education, Madrid.

FLOYD L. Thomas. (2008), "Electronic Devices". Eighth Edition. Pearson Education, Mexico.

MALONEY, Timothy. J (2009), Modern

Industrial Electronics. Third edition. Prentice Hall. Mexico.

5. Gratitudes

Thank infinitely the help of God, be wonderful that gave us the strength to successfully complete the race, the Technical University of North for their welcome and become better people and to serve the country as well as the different teachers they gave their knowledge and support to keep going day by day and which over the years became an example to follow.
Our undying gratitude to the Engineer Pablo Mendez, for giving us the opportunity to use its skills and scientific knowledge to successfully complete the new goal.

Altamirano Edgar
Y
Méndez Paul

6. About the Authors

Edgar Polibio ALTAMIRANO PINCHAO, I was born on June 16, 1987 in the province of Carchi. My primary instruction in the school perform Julio Martinez Acosta city of Tulcan, at the end enters the Technical Institute Vicente Fierro, where I got the title of Technical degree in Electricity. Finally enter the Technical University of the North in Engineering in Electrical Maintenance, for the title of Electrical Maintenance Engineer.

Paul David MENDEZ CAICEDO, I was born on May 20, 1988 in the province of Carchi. My primary instruction the Attorney perform in school children Abdon Calderon, at the end enter the Catholic particular educational unit Dario Egas Grijalva where I got the title mathematical physicist, Finally enter the Technical University of the North in Engineering in Electrical Maintenance, for the title of Electrical Maintenance Engineer