Indian Journal of Science and Technology, Vol 11(42), DOI: 10.17485/ijst/2018/v11i42/132756, November 2018
ISSN (Print): 0974-6846
ISSN (Online): 0974-5645

Temperature Control for Stress Tests in TV Decoders

Ludvigs A. Ayala P, Julián R. Camargo L and César A. Perdomo Ch*

Engineering Faculty, Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia;
laayalap@correo.udistrital.edu.co, jcamargo@udistrital.edu.co, cperdomo@udistrital.edu.co

Abstract

Objectives: To show the development of a solution for the temperature control of a quarter of stress tests where the equipment is subjected to extreme temperature conditions (controlled) for a short time and to ensure that the integrated circuits are not defective or the welding points are crystallized. **Methods/Analysis:** For this purpose, a temperature control is designed using the LM35 low cost commercial temperature sensor and RS485 serial communication between a PSoC5LP and the LabVIEW program for information processing and system control. **Findings:** To obtain good results, one must be certain about the maximum temperatures at which the equipment can be subjected, also know the most adverse temperature conditions to which an electronic equipment may be subjected in real life and thus avoid the damage of these so that it produces more electronic garbage that every year, due to the demand and the technological advance, is greater. **Improvements:** The designed control system can be implemented in a low cost computer such as a Raspberry Pi making the system much more versatile.

Keywords: BURN-IN, LabView, PSoC, RS485, Serial Communication

1. Introduction

The amount of electronic waste generated on the planet is impressive, for 2005 "In the Colombian case, 60,000 tons of e-waste are generated annually"[1]. Today, it is estimated that in Colombia, for example, about 252,000 tons per year of waste of this type are produced[2].

The most common waste are: computers, tablets and cell phones; but also include refrigerators, washing machines, televisions, microwave ovens, sound equipment, video, irons, dryers, coffee makers and blenders. Of all these things that can be recovered to be repaired and reused are computers, tablets and cell phones. The totality of these residues cannot be mixed with domestic garbage; they must be disposed of in a special way, either the destruction and recycling or the reuse of them[3].

In the refurbish lines of TV decoder equipment it is necessary to perform a "hot" functionality test, that is, that the equipment is subjected to temperature stress for a period of at least 3 hours (180 min) and no greater at 4 hours (240 min). In this stress test, the equipment is brought to a predetermined maximum temperature to ensure that the electronic components work properly in extreme conditions and the welds on the motherboard are not crystallized, to ensure the correct functionality of this equipment for a longer time.

The decoders are entered into a room (oven type) where they will remain connected for a maximum of 4 hours and with a temperature as constant as possible. Once 3 hours have passed, these devices are subjected to a functional test, this test will be done without the equipment being disconnected, in order to avoid that they get to cool down by removing them from the oven.

For this, a maximum temperature limit must be guaranteed in the furnace so that the equipment is not damaged in the process and can monitor the temperature of each decoder so that they do not suffer from a very long test. To this end, LM35 temperature sensors and PSoC5LP systems were used to process the signals to be monitored by means of a computer communicated by RS485, and the actuators needed to comply with the process conditions were controlled by this same channel.

*Author for correspondence

In the reconditioning line of TV decoders, it is necessary to do two tests to the decoders. The first is the cold diagnosis, which is done after the equipment enters the production line, from here it is decided whether the equipment will be repaired or cleaned and then leads to the stress test, called BURN-IN[4], in which the decoders are subjected to temperatures of 25°C to 50°C for a time not exceeding 4 hours, this to ensure that the equipment can operate at various temperatures in the place where they will operate. Then it makes the diagnosis in hot, where the decoders are checked in extreme temperature conditions to ensure its operation. In Figure 1, a process diagram is shown.

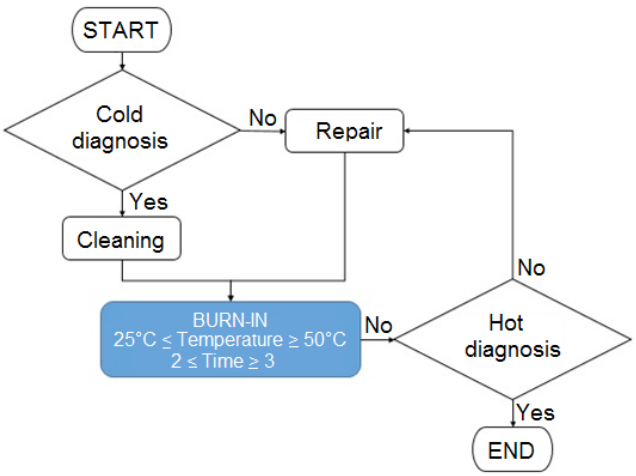

Figure 1. Flow diagram of the process of entry to cold diagnosis and hot diagnosis output.

As the decoders are not new, but are repaired and reconditioned, they must necessarily pass through the BURN-IN test, which helps identify those decoders that are not ready, since defective integrated circuits are more prone to fail at high temperatures, in the same way welds that are beginning to crystallize can present contact faults and the decoders stop working properly.

The problem in a manual type test system is that they do not have any kind of control, so the equipment that enters the test room, does not have any control system for the time they are in the oven or the temperature at the which are tested. This causes the decoders to be subjected to temperature conditions that exceed normal operating levels, putting at risk the electrical integrity of the integrated circuits of the decoder.

Those decoders that manage to finish the temperature test must be tested in their operation. The decoders must be tested while they are at the temperature of the test that is up to 50°C but for non-automated systems this cannot be assured since the decoders are disconnected and taken out of the oven, so these are cooled and the tests are not the most reliable, because the decoders are often returned by guarantee.

Below is a solution for the part of controlling the temperature and time of the decoders in the oven.

2. Test System Design

For the design of the control it is necessary to know the requirements of the system. The control system must be responsible for maintaining the temperature constant in a quarter of temperature stress tests, where the television decoders, which have been repaired or are reused, remain at least 2 hours and maximum 4 in constant operation, this value Time is programmable; this in order to verify that the integrated circuits can operate correctly at a programmed temperature between 25°C and 50°C.

Figure 2 shows how it was proposed to perform the temperature control in the BURN-IN oven, it is observed that a defined number of racks can be entered, which will have an MCx Control Module where x is the number that identifies each module. Which is responsible for receiving the signals from the temperature sensors (yellow wires to the right of the DECOs) and adapt the signal to be processed by the PSoC, this also gives the signal (green wires to the left of DECOs) to a relay to disconnect power to a DECO that is working at a higher temperature than the one programmed in the Master Control; the connection between the MCx (slave modules) and the master control (Computer) will be made through RS-485 serial communication that allows multiple slave modules to be connected to a single master control[5]. The MCH is a control module that constantly measures the temperature of the BURN-IN oven to activate or deactivate the hot air extractor.

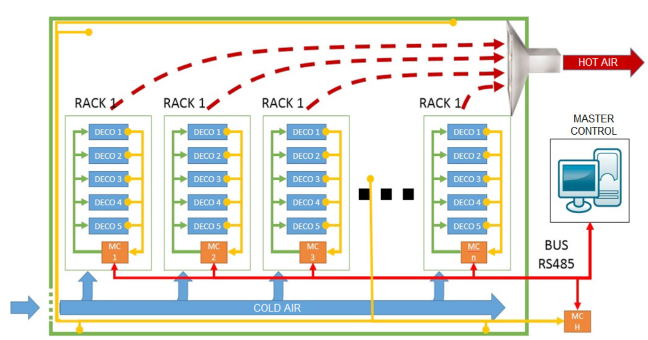

Figure 2. The proposed control system to regulate the temperature of the decoders.

2.1 Temperature Measurement and Signal Conditioning

In this stage, the sensors and the most suitable device were chosen for the treatment of the signals of the sensors and the control signals, the location of them, the conditioning of the signal in order to process the data and send them to the master module.

The temperature conditions do not demand a very sophisticated sensor and even not very expensive; for that, it is decided to use the LM35, which is an integrated circuit that tolerates the temperatures at which it is going to work, its response is linear with increments of 10mV/°C and an accuracy of 0.5°C[6]. These conditions comfortably meet the design needs.

For the choice of the controller, the number of ADC channels necessary for the process of the five decoders that would be in a single rack, the serial communication protocol, was taken into account. For this the PSoc5LP is chosen, for its characteristics of the input / output pins, analog to digital converters, UART serial communication and temperature tolerance and electromagnetic noise[7].

Adapting the signals coming from the sensors, and the signals sent to the actuators is essential so that the acquired data are the most adequate and there are no errors when making the decisions for those who will exercise the control action. The suitability of the signals depends on the location of the control module and the distance it is from the LM35 sensors.

To condition the signal from the temperature sensor, the circuit of Figure 3 was used, this type of connection is recommended since the control module will be at a distance of maximum 1 meter from the sensor, and this configuration is appropriate to avoid electromagnetic noise UTP cable of 4 pairs CAT5 was used to connect the LM35.

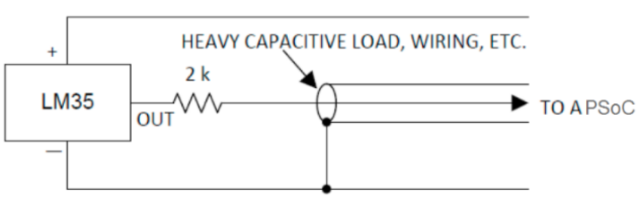

Figure 3. Connection and signal conditioning of the LM35 to the PSoC5LP.

The organization and distribution of the sensors and the location of the control module is shown in detail in Figure 4. This distribution is used for each of the racks that contain 5 decoders. In each rack there will be an array of relays activated by the control module, which are responsible for de-energizing the decoders independently. The relays were located on a separate card of the control module to avoid electromagnetic and mechanical noise having any effect on the communication of the control modules and the master control.

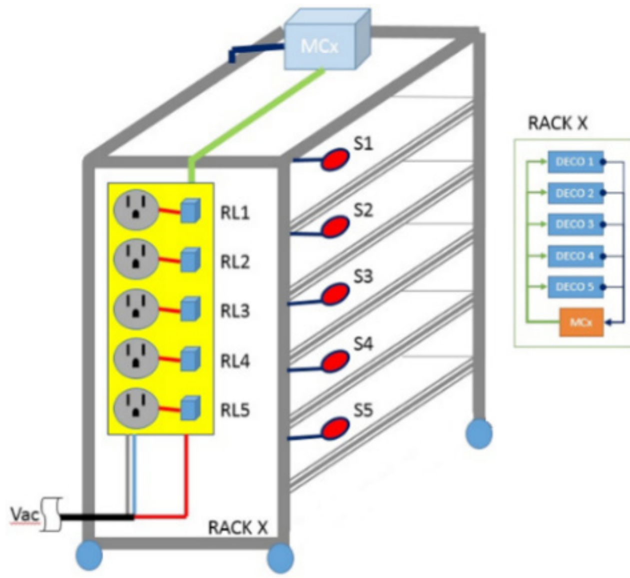

Figure 4. Test rack design for 5 TV decoders.

The MCx is where the PSoC5LPs are in charge of receiving the signal from the LM35 sensors, while the relay arrangement was organized on a printed circuit designed and manufactured for that purpose. The relays used are normally open relays that, in case of failure, will be opened to protect the equipment in the BURN-IN furnace. According to the power consumption of the decoders, between 15Watts and 80Watts depending on the model, we look for a relay that operates at these powers, taking into account that the network voltage is 110V; the working current of these decoders is maximum 750mA approximately. The relay chosen supports a current of up to 1.5A. For ease of price and availability in the market 5-pin relays, 5VDC solenoid and operate at 5A or 10A to 120/240VAC are used.

The connection of the control modules to the RS485 bus was done with four-wire RJ11 JACKS, as shown in Figure 5. The black (B) and red (R) cables carry the polarization voltage for the MCx (5Vdc) and the Green (G) and yellow (Y) cables carry the RS485 bus. This makes connecting and disconnecting the racks to the bus very easy.

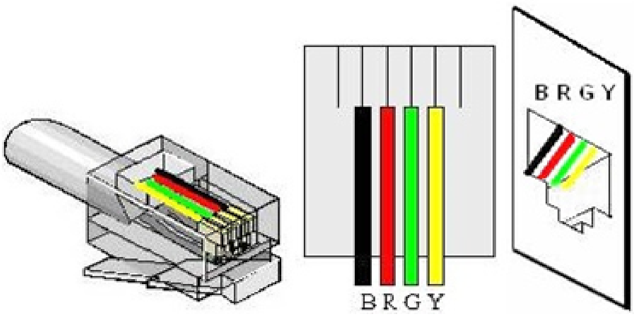

Figure 5. 2 pair RJ11 connector wiring[10].

2.2 Development of Algorithms

For the development of the PSoC5LP algorithm that controls the MCx control modules, the PSoC Creator V4.1 software that provides the Cypress (the PSoC manufacturer) was used for free, with which you can perform all the configuration, programming and simulation of the PSoC. The PSoC® Creator is an environment that allows the co-design of software and hardware to be programmed in all PSoC3, PSoC4, PSoC4BLE and PSoC5LP devices. It has a list of more than 200 components that have been pre-designed which can be configured depending on the particular requirements of each implementation. In addition to this, the PSoC Creator allows the design of new components that are required for specific functions that are not covered by the existing components7. For the master control (PC) LabVIEW was used.

The development of the PSoC program (control modules) is divided into two parts: first, the acquisition of data from the temperature sensors and control outputs of the relays; and second, the communication between the control modules and the master control. For what will be used as a reference the MODBUS RTU8 protocol on RS-485 communication.

Figure 6 shows the blocks of the PSoC5LP that were used to connect the temperature sensors, the relays and the communication with the MAX487 module that allows the connection to the RS-485 bus. The PSoC pins used to communicate with the master control are those corresponding to the UART port (the UART block allows direct connection to the RS485 bus), the sensors are connected to the analog pins and these in turn with the analog converter to digital, and finally the actuators are connected to digital outputs that by means of resistors and NPN transistors provide sufficient current to activate the relays that connect and disconnect the power cables of the decoders.

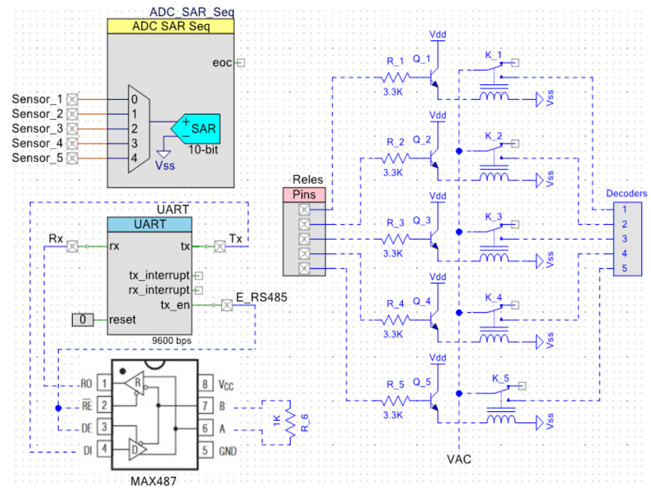

Figure 6. Configuring the I/O pins of the PSoC5LP.

The second part of the program receives its own frame, based on the MODBUS model, which comes from LabVIEW through the COM serial port and is analyzed byte by byte to decide what action to take, if the data taken by the analog ports, coming from of the temperature sensors or if the control byte must be sent to the port called Relays to activate or deactivate the relays. Figure 7 shows the fields of a typical MODBUS frame and the own frame that was used for this implementation.

MODBUS frame

No. Slave (00-3FH)	Operation Code	Sub functions, Data	CRC (P16) H L

Own frame

No. Slave (00-3FH)	Operation Code	Error check

Figure 7. Fields of frames used.

The own plot is divided by fields and in this way it is evaluated to make the necessary decisions for the control of the relays. With reference to the table of basic functions of the MODBUS sees (Table 1), only the codes 03H and 06H are used, since they are the only data that are transferred between the control modules and the master control. Given the versatility of the implemented algorithm, the functions that are necessary can be added from Table 1.

Table 1. Function code MODBUS

Task	Code	Function
0.	00h	Control of slave stations
1.	01h	Reading of n output or internal bits
2.	02h	Reading of n input bits
3.	03h	Reading of n output or internal words
4.	04h	Reading of n input words
5.	05h	Writing a bit
6.	06h	Writing a Word
7.	07h	8-bit quick Reading
8.	08h	Control of diagnostic counters number 1 to 8
9.	09h	Not used
10.	0Ah	Not used
11.	0Bh	Control of diagnostic counters number 9
12.	0Ch	Not used
13.	0Dh	Not used
14.	0Eh	Not used
15.	0Fh	N bit writing
16.	10H	Writing n words

Figures 8-9 show the flow diagrams of the algorithm implemented in the PSoC5LP. In essence the PSoC constantly receives the signal from the LM35 temperature sensors, making the conversion from analog to digital, saving this information in a data array (Sensor [x], where x is the number of the decoder being evaluated). The output signals for the relays are activated when indicated by LabVIEW. The data from the sensors are sent to the master control whenever LabVIEW requests it, and in the same way the master control sends the values of the relay states that control the electrical connection of the decoders. For this process, a proprietary communication protocol based on MODBUS RTU is used.

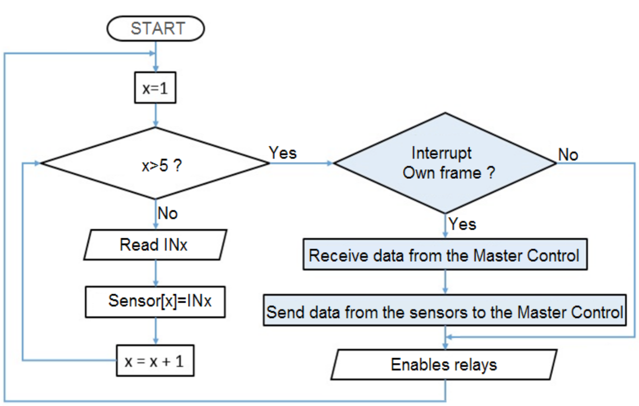

Figure 8. Reading and writing cycle of the input and output ports.

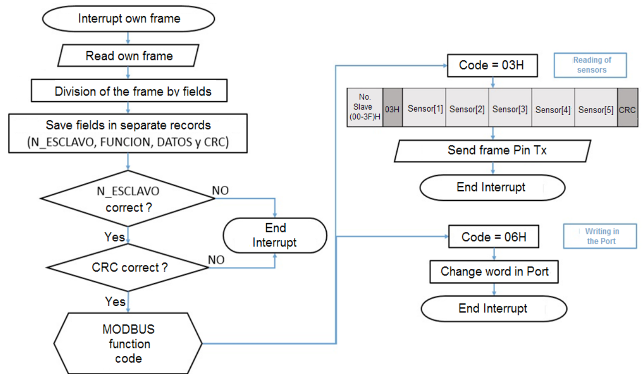

Figure 9. Interrupt by MODBUS transmission.

To complete the process of designing the application, LabVIEW[9] developed the control system with the following parameters: First, serial communication through the LabVIEW VISA function, the configuration is: 9600.8bits, n, 1. Second, an automatic cycle, which constantly sends and receives data from the MCx, reads the data from the PSoCs and sends the data containing the information on the actions to be taken with respect to the activation or deactivation of the decoders and the air extractor hot. Third, buttons with which the same process is done before, but manually. Fourth, a set of graphs that show the values of the temperatures of each control module and, in addition, the state of the decoder that does not meet the temperature condition, likewise the activation of the extractor if the desired temperature is exceeded. Fifth, a CVS file is generated to be able to make reports in Excel and Sixth, accounting for the BURN-IN time, which is programmed by the user.

Figure 10 shows the communication of each of the blocks of the system (PSoC5LP, LabVIEW, sensors, relays that energize the decoders and the air extractor). From the LabVIEW block you can see that the user sets the initialization values: The COM serial communication port, the control reference temperature of the system, the duration of the automatic cycle in minutes and the duration of the BURN test. -IN. Once this is configured, the program starts with the automatic sequence, this sequence consists of the request of the temperatures of the first slave, the frame arrives at the PSoC of the first slave, acquires the data through the analog port and makes the conversion to 10 bits justified to the left to convert the converter data to 8bits, the PSoC sends the response frame to LabVIEW. LabVIEW receives the plot, analyzes it and makes a comparison of the values of each sensor with the reference temperature and makes the decision to keep the decoders that fulfill the condition on and turn off those that do not comply, writing in the port of the PSoC the values corresponding to the On / Off of decoders or air extractor. After this it continues with the same process but for the second slave and so on. In case the user presses the update button of a slave, LabVIEW will perform the same sequence explained in the previous paragraph, only that when finished it will restart the automatic sequence with the first slave.

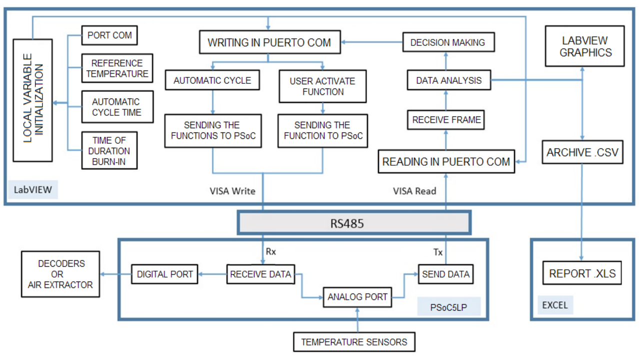

Figure 10. Block diagram of system connections.

3. Results

Figure 11 shows the interface with the user of the master control system and control modules. The interface with the user is very intuitive. On the left are the configuration and temperature monitoring tabs and on the right the graphs of the temperatures with respect to time. For tests, the interface system with the COM3 port is configured, the automatic cycle time is set to 1min, the reference temperature is 50°C and the BURN-IN time is set at 180min which is the minimum time of BURN-IN.

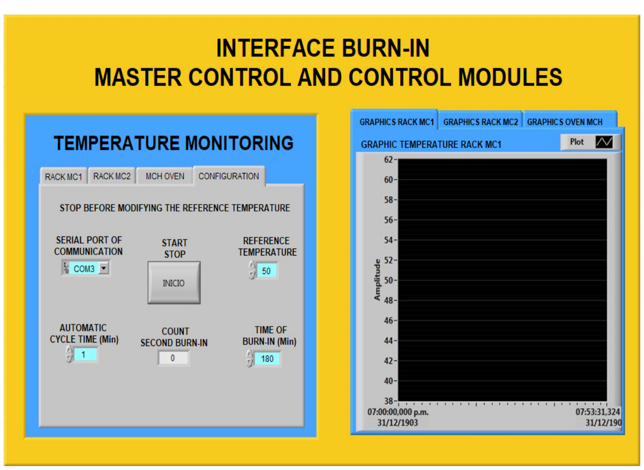

Figure 11. User interface in LabVIEW.

Figure 12 it shows the MC1 Rack where the decoders 1, 2, 3 and 4 have a higher temperature than the reference, so they are off, as shown by the green indicator, while the decoder 5 is on, because its temperature is less than the reference.

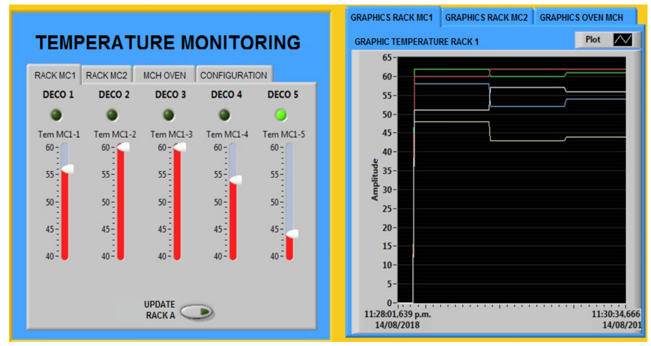

Figure 12. MC1 Rack temperature monitoring.

The MC2 rack of Figure 13 shows all decoders turned on since their temperature values do not exceed the set limit temperature.

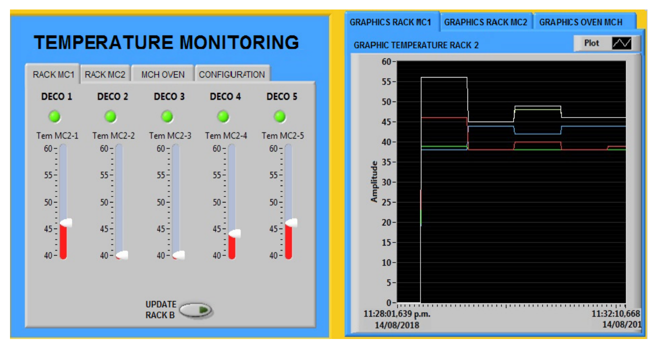

Figure 13. MC2 Rack temperature monitoring.

Figure 14 shows on the right side that the average temperature of the sensors is higher than the limit temperature and this makes that as shown in the left part of the image the extractor turns on.

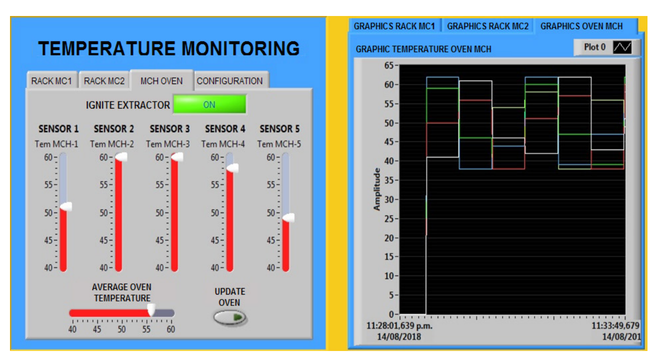

Figure 14. Monitoring the temperature of the MCH Oven.

4. Conclusions

Automatic systems make it easier to control multiple variables, and in this specific case, the ease of monitoring the temperature of a desired number of devices.

The use of half-duplex serial communication of the RS485 allows more control modules to be added to the system. The programs of the PSoCs do not change from one to another, since when an identifier is assigned to each slave, only the slave will respond to the teacher's request.

After evaluating the costs of preparing the prototype, it is concluded that it is a low budget project, making it completely viable.

5. Acknowledgments

The authors would like to thank to the Universidad Distrital Francisco José de Caldas and the LASER research group that supported the development and testing of the project.

6. References

1. Mayorga FA. Dise-o de un modelo de gestión del conocimiento aplicado a un proyecto de reciclaje electrónico de impresorasen la Facultad de Ingeniería de la Universidad Distrital Francisco José de Caldas. Universidad Distrital Francisco José de Caldas; 2011.
2. Diario El Tiempo. Redacción Vida/Ambiente. ¿A dóndel levar la basura electrónica? 2015. Date accessed: 02.06.2015. https://bit.ly/1Quv4zi.
3. Ministerio de Tecnologías de la Información y las Comunicaciones, Ministerio de Educación Nacional, Computadores para Educar. CPE Documento técnico para discusión de especificaciones mínimas para la adquisición de tabletas, portátiles, servidores y sistemas; 2015.
4. MailxMail.com. Capítulo 6: Pruebas Masivas (Burn-In o Stress Tests). Date accessed: 14.07.2004. http://www.mailxmail.com/curso-virus-ataques-externos-prevencion-eliminacion/pruebas-masivas-burn-in-stress-tests.
5. Forero Saboyá N. Normas de Comunicaciónen Serie. 2012: RS-232, RS-422 y RS-485, Revista Ingenio Libre. 2014; 13:86–94.
6. Texas Instruments. LM35 Precision Centigrade Temperature Sensors; 2017. Date accessed: 12/2017. http://www.ti.com/lit/ds/symlink/lm35.pdf.
7. Camargo JR, Perdomo CA. Introducción al PSoC5LP: Teoría y aplicaciones prácticas. Bogotá: Ed. Universidad Distrital Francisco José de Caldas; 2016. p. 1-24.
8. National Instrumens. The Modbus Protocol In-Depth. Date accessed: 07/03/2017. http://www.ni.com/white-paper/52134/es/.
9. Jerome J. Virtual Instrumentation Using Labview. Prentice Hall India Learning Private Limited; 2010. p. 1–416.
10. Hansen C. Network Wiring Instructions. Cable Organizer. Network Wiring Instructions; 2018.