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Original Article

Smart Home using LabVIEW and Microcontroller

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Abstract - *This research paper aims to develop a Smart Home system using LabVIEW and Microcontroller, Bluetooth link, and various electronic components. It explains a home automation control model that should exist in a residence. In addition, a user-friendly interface was designed using LabVIEW engineering software. First, the user logs in and then accesses the controls to manage the lighting in the living room, dining room, and bedroom. Temperatures are monitored, and the history is kept through a database. The electronic schematic was done in Proteus software; the uC programming was done in C language. The findings of this research demonstrate the behavior and trends of the temperature when a user enters a residence; it is also possible to visualize the activation of luminaires and alarms for the dining room, bedroom, living room, and garden. This flow of actions ensures that the authenticated user can easily and conveniently manage lighting options, alarms, etc., in the different areas mentioned.*

Keywords - *Smart home, Integration of electronic components, Bluetooth, Microcontroller, LabVIEW.*

1. Introduction

Currently, the world's smart home is an important trend; using modules designed in smart home applications where user comfort, such as electrical safety, is required should be considered [1]. In this regard, the Internet of Things (IoT) is rapidly developing for use in smart environments, including smart homes, etc. [2]. The advancement of science and technology is making life easier. Today, the world is accepting automation over traditional systems [3]. This research proposes a simulation and control framework for a residence, focusing on various processes such as lighting and alarm control [4]. In addition, thermal management becomes necessary for a longer life of the residence [5]. In that sense, it seeks to integrate sensors and databases for home automation, and if there is a problem, it will immediately identify it and try to solve it. In that case, a notification will be sent to the homeowner [6].

For the above-mentioned, this research proposes to analyze what are the effects of the development of a home automation system using *LabVIEW* engineering software and the PIC 16F8877A microcontroller. Therefore, the importance of this research lies in its focus on developing a domotic system using the *LabVIEW* Engineering software and the PIC 16F8877A microcontroller. Domotics is an emerging field that seeks to integrate technology in home automation and control, providing comfort, energy efficiency, and security benefits. By analyzing the effects of this system, the research seeks to provide relevant information on how the *LabVIEW* Engineering software and the PIC 16F8877A microcontroller can affect the implementation of a home automation system. This can help engineers and designers better understand the capabilities and limitations of these particular elements, allowing them to make informed decisions to develop more efficient home automation systems.

On the other hand, the objective of the research is to evaluate the effects of the domotic system using the *LabVIEW* engineering software and the PIC 16F8877A microcontroller. By obtaining concrete results, it will be possible to identify both the benefits and possible limitations or challenges associated with using this software and microcontroller in the home automation context. In this way, contribute to the advancement of home automation through findings that provide valuable information for future projects and improvements in system design, with practical applications in smart homes, commercial buildings, etc.

2. Materials and Methods

The methodology used in this research was the agile Kanban-type methodology, which allowed the distribution of the tasks to be performed efficiently. In the development of the domotic system, different hardware components were considered, such as LM35 sensors, actuators such as alarms, and microprocessors, among others [7].

The integration of all electronic components was performed using Proteus Software, then proceeded to perform the programming of the PIC 16F8877A Microcontroller using PIC C COMPILER software, which is an extensible and highly configurable software program that incorporates powerful tools to help discover, configure, develop, debug, and qualify embedded designs for most microcontrollers and digital signal controllers [8].

Then, for monitoring the temperature, lighting, and alarm control system, it proceeded to interface with LabVIEW, a system engineering software for applications requiring testing, measurement, and control with fast access to hardware and data information [9].

Finally, the integration of the diagram made in Proteus and LabVIEW was performed. The tasks to be performed are detailed below.

2.1. Integration of Electronic Components

In this phase, the integration of various components was carried out in Proteus since interfaces and connections play a fundamental role in the manufacture and application of electronics [10]. This process allowed the combination of different components to create complete and functional devices, ensuring proper operation and performance in the developed electronic system. The integration of the components using proteus software is detailed below.

The air temperature sensor (LM35) measures the ambient temperature [11]. In the investigation, three sensors have been considered for the dining room, bedroom, and living room; in case a temperature above 100°C is detected, the alarms of each bedroom will be activated (see Figure 1).

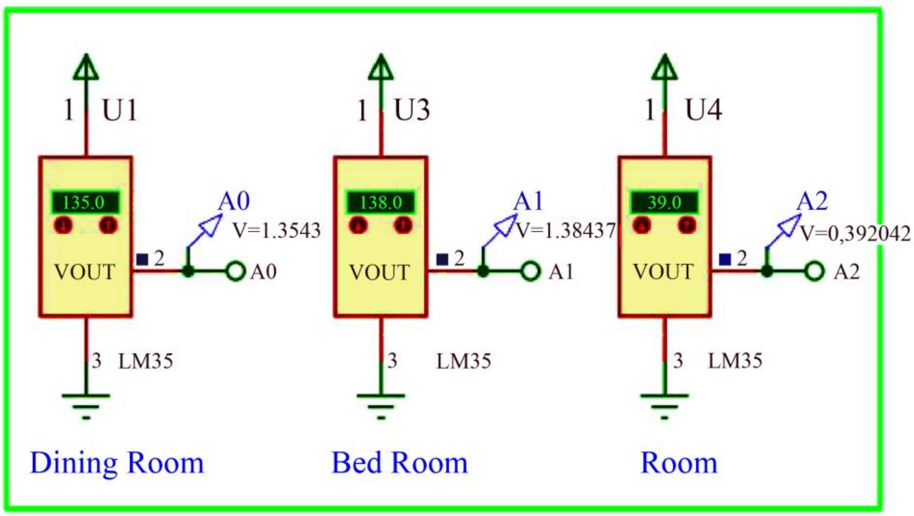


Fig. 1 LM35 sensor for dining room, bedroom, and living room

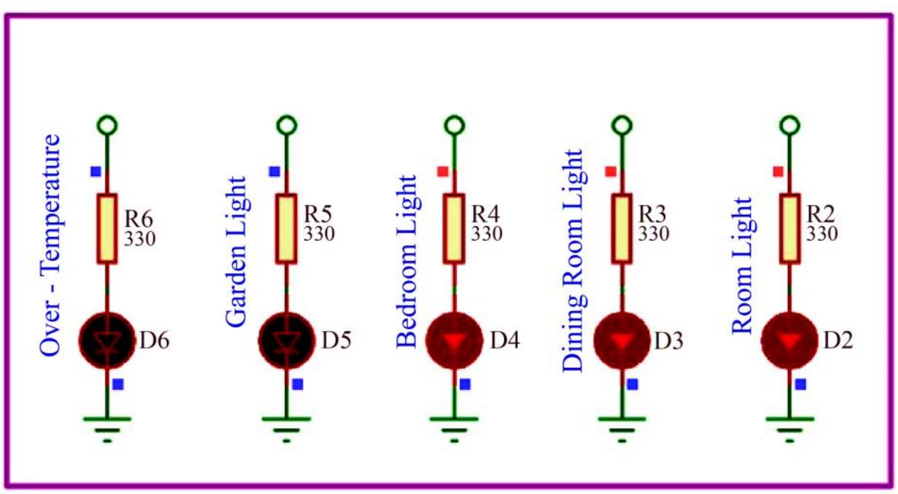


Fig. 2 Light indicator for garden, bedroom, dining room, living room, and Over-temperature

Figure 2 shows the LED-type light indicators for the bedroom, dining room and living room. In this regard, LEDs with a narrow emission band should be specially selected so that their spectra do not overlap each other [12]. Figure 3 shows the connections of the PIC 16F8877A using Proteus software. This component has been chosen because of its very good performance, programming facilities, availability, and economic advantages [13]; it is a powerful 8-bit FLASH CMOS-based microcontroller (200 nanosecond instruction execution) but easy to program (only 35 single-word instructions) includes Microchip's powerful PIC® architecture in a 40 or 44-pin package and is upward compatible with the PIC16C5X, PIC12CXXX, and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, auto programming, an ICD, 2 comparators, 8 channels of 10-bit analog to digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as a 3-wire serial peripheral interface (SPI™) or 2-wire inter-integrated circuit bus (I²C™) and a universal asynchronous receiver transmitter (USART). All these features make it ideal for more advanced level A/D applications in automotive, industrial, appliance and consumer applications [14]. Finally, connections were made using the oscillator, LCD display and Bluetooth (see Figure 4).

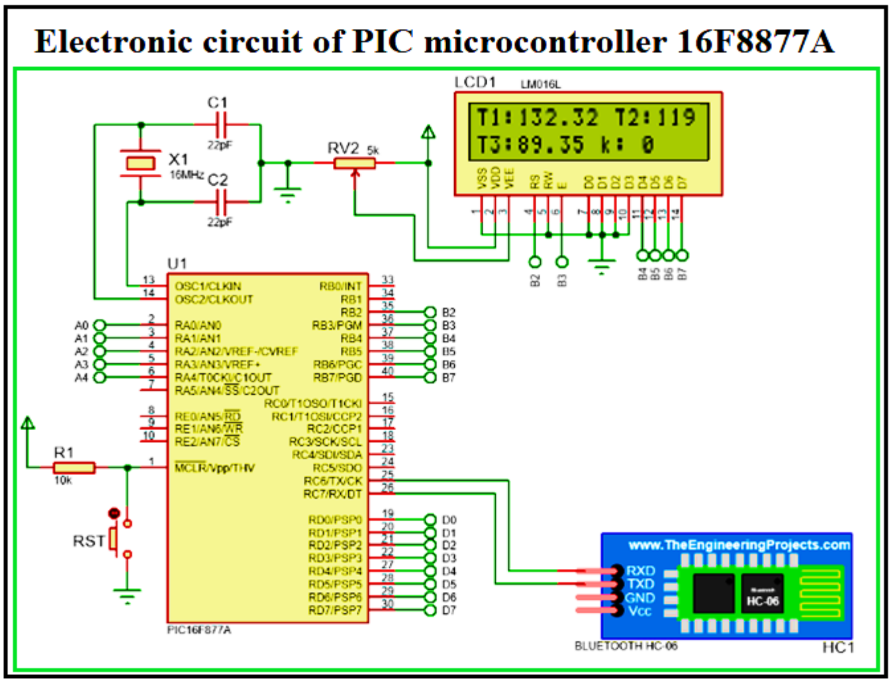


Fig. 3 PIC 16F8877A Microcontroller connections

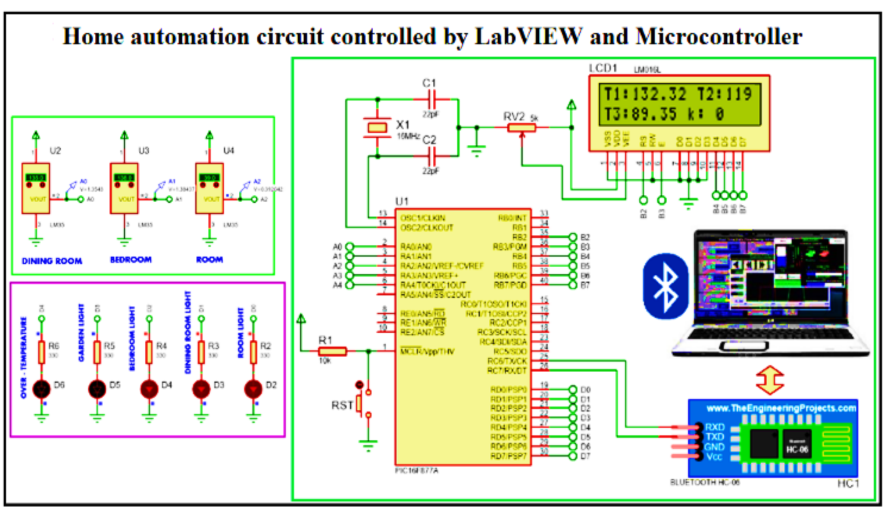


Fig. 4 Electronic circuit for home automation controlled by LabVIEW and PIC 16F877A microcontroller

Figure 5 shows the programming of the PIC 16F8877A Microcontroller using C language. The program is presented below:

```c
#include <16F877A.h>
#device adc=10
#FUSES HS,NOWDT
#use standard_io(D)
#use delay(clock=16000000)
#use rs232(baud=9600, xmit=pin_c6, rcv=pin_c7, bits=8, parity=N)
#define LED0 PIN_C0

#define use_portb_lcd TRUE //define portb lcd
#define LCD_DB4   PIN_B4
#define LCD_DB5   PIN_B5
#define LCD_DB6   PIN_B6
#define LCD_DB7   PIN_B7
#define LCD_RS    PIN_B2
#define LCD_E     PIN_B3

#include <lcd1.c>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

// Definicion de salidas
#define  Motor1   PIN_D0
#define  Motor2   PIN_D1
#define  Motor3   PIN_D2
#define  Motor4   PIN_D3
#define  Motor5   PIN_D4
// Variables para las cargas
unsigned int8 cargas= 0;
const unsigned int demo=1;
char data_cargas[6];
char dato_rx='\0';
unsigned int8 dato_x=0;
//char pase[10];
char k;

#int_rda
void Serial_ISR(){
   dato_rx=getch();
}

void main() {
   unsigned int16 A1,A2,A3;
   float TempComedor,TempDormitorio,TempSala;
   setup_adc_ports(all_analog);
   setup_adc(ADC_CLOCK_DIV_2);
   lcd_init();
   lcd_gotoxy(1,1);
   lcd_putc("Iniciando ...");
   delay_ms(1500);
   lcd_gotoxy(1,1);
   lcd_putc("Transmitiendo ");
   lcd_gotoxy(1,2);
   lcd_putc("datos por RS232 ... ");
   printf("******************************************************** \r");
   printf("\n****** ADQUISICION DE DATOS ANALOGICOS POR RS-232 ******* \r");
   printf("\n******************************************************** \r");
   output_D(0xCC);
   delay_ms(1500);

   enable_interrupts(int_rda);
   enable_interrupts(global);

   for (;;) {

      set_adc_channel(0);
      delay_us(100);
      A1 = read_adc();
      TempComedor = 0.488281*A1;
      //TempComedor = 500 * A1 / 1024.0;

      set_adc_channel(1);
      delay_us(100);
      A2 = read_adc();
      TempDormitorio = 0.488281*A2;

      set_adc_channel(2);
      delay_us(100);
      A3 = read_adc();
      TempSala = 0.488281*A3;

        printf("T1: %02.3f - T2: %02.3f - T3: %02.3f  k: %c \n\r",
        TempComedor,TempDormitorio, TempSala, dato_rx);
        lcd_gotoxy(1,1);
        printf(lcd_putc,"\fT1:%2.2f T2:%2.2f ",TempComedor,TempDormitorio);
        lcd_gotoxy(1,2);
        printf(lcd_putc,"\T3:%2.2f k: %d ",TempSala, dato_rx);
        conv_bcd_binario(dato_rx);
        output_low(LED0);
        delay_ms(3);
        output_high(LED0);
        delay_ms(3);

        }
  }
```

Fig. 5 Programming the PIC 16F8877A microcontroller in C language

2.2. LabVIEW Interface Development

The following are the stages of Interface Development in LabVIEW.

2.2.1. Login Interface Design

The login interface allows the user to have a better perspective of the working environment [15]. Using a username and password for IoT firmware security is vital because it avoids revealing confidential data since the users and passwords are encrypted, preventing future attacks and breaches of IoT devices [16, 17]. Figure 6 shows the development of Sub VI for the database code in Excel. On the other hand, Figure 7 shows the Sub VI of the Login validation.

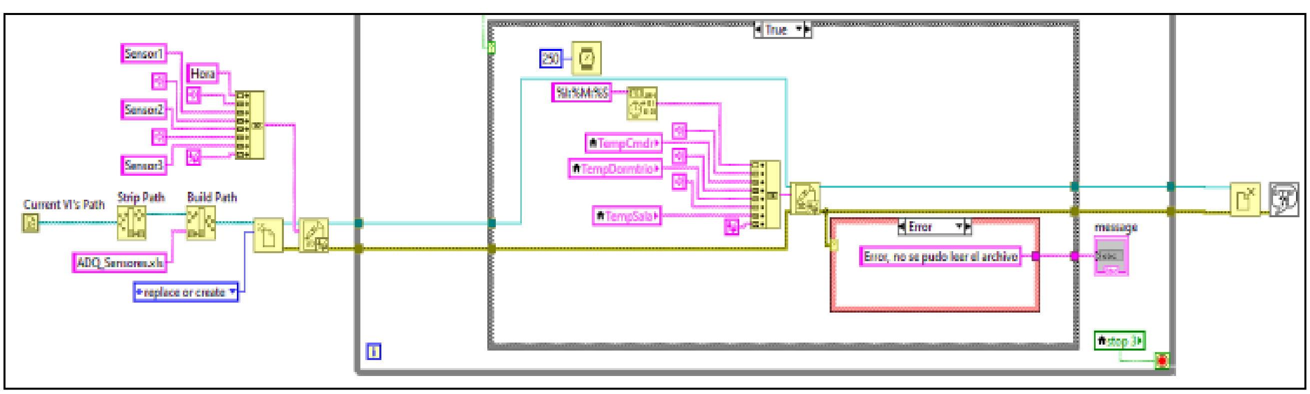


Fig. 6 Code for excel database

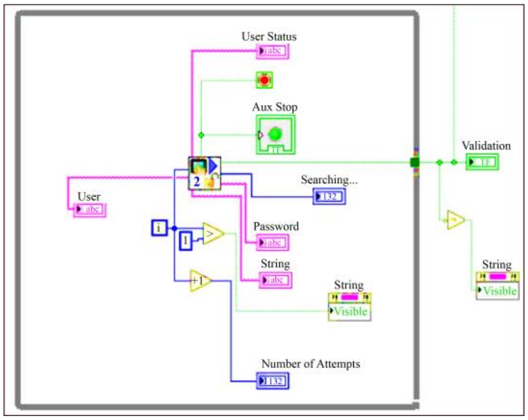


Fig. 7 Login validation

With respect to Figure 8, in the system startup interface, a lockout has been implemented after 3 failed attempts. In addition, the system allows the authentication of multiple users with different names and passwords. At all times, the user is required to log in, with a limit of attempts, and once logged in, the user can access the controls.

Fig. 8 Startup interface

Figure 9 presents the database interface, which is crucial as it allows only a specific group to access the system using their corresponding usernames and passwords. This functionality is of great importance to ensure the security and access control of the system.

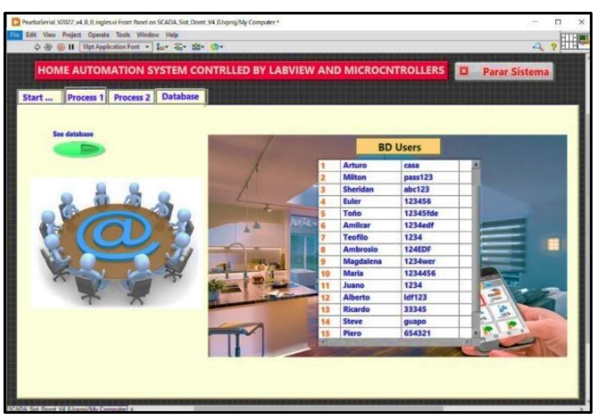


Fig. 9 Database interface

2.2.2. Design of the Temperature Monitoring Interface

In this phase, the temperature monitoring interface will have active alarms for preset temperature control in the LabVIEW interface. The design of a high-temperature test system using LabVIEW and processor hardware can monitor voltage and current generation and input and output temperatures [18]. As seen in Figure 10.

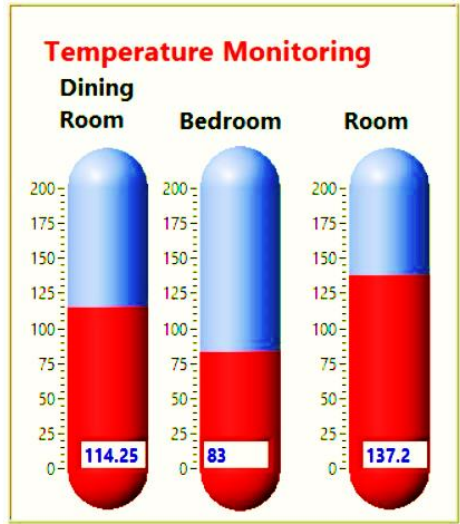


Fig. 10 Design of the temperature monitoring interface

2.2.3. Process 2 Interface Design

In Figure 11, the on/off control of a house's living room, bedroom, dining room, and garden can be seen. This visual representation provides a clear view of how lighting is managed in different areas of the house, allowing convenient and efficient control for the user.

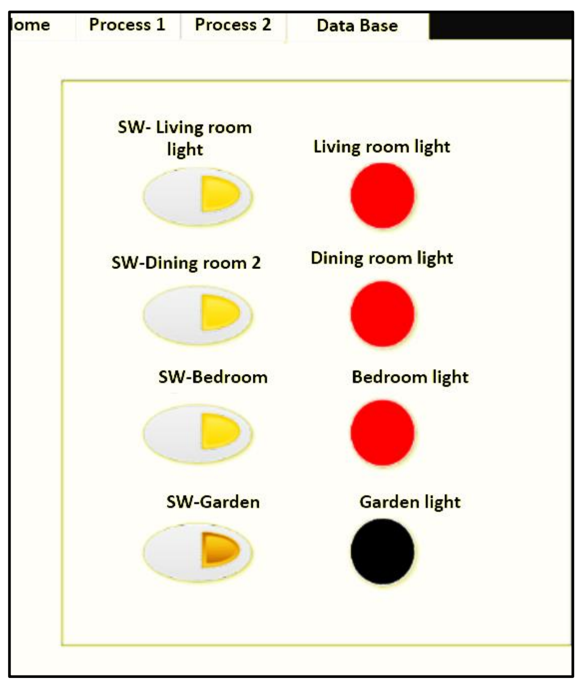


Fig. 11 Process interface design

2.2.4. Design of the Temperature Graph Interface

In this phase, I proceeded to create the interface in LabVIEW to visualize the curves that show the variation of the temperature of the luminaires in the living room, dining room, and bedroom according to the reference value. In the graphical interface of the temperature, the details of the structural and significant changes of what is to be controlled are visualized [19]. As shown in Figure 12.

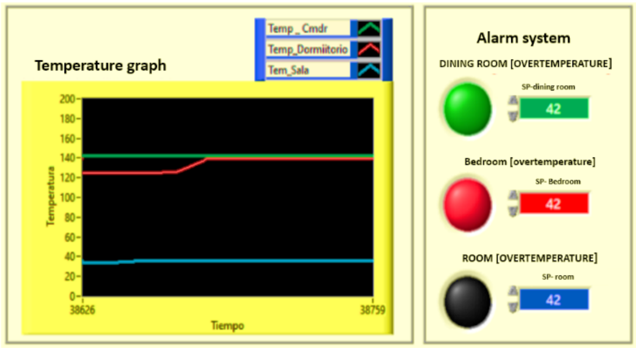


Fig. 12 Design of the temperature graph interface

2.2.5. Alarm System Interface Design

The use of alarms is closely related to microcontrollers. In-home automation, the home security system is closely related to the alarm because, in many cases, it allows the door and window to open automatically [20]. In this research, an alarm system interface has been developed to detect temperatures above 42 degrees, as shown in Figure 13. This functionality is of great importance for the safety and security of the home, allowing an immediate response to high-temperature situations.

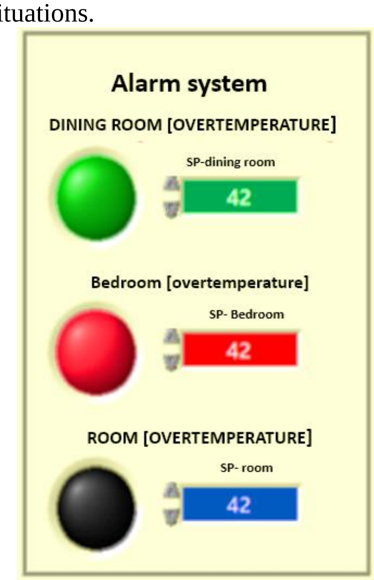


Fig. 13 Alarm system interface design

2.2.6. Design of the interface Vista Name and Baude Rate

The microcontroller port view interface was designed, as well as the 9600 baud rate. Nowadays, automation is required everywhere to save time and effort [21]. As it appears, "Smart Home Using LabVIEW and Microcontroller"ared in Figure 14.

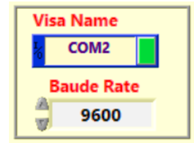


Fig. 14 Name view and baude rate interface

2.2.7. String Read

The microcontroller sends temperature data from the dining room, bedroom, and living room to the PC through a Bluetooth connection. Then, through programming algorithms, each variable is extracted and monitored individually in the Waveform Chart, as shown in Figure 15. This methodology allows efficient and detailed monitoring of temperatures in different areas of interest.

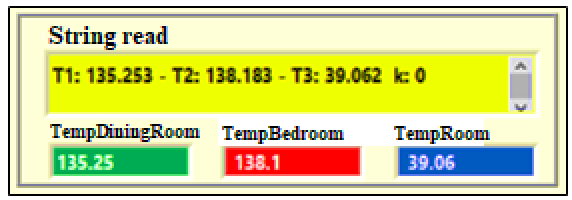


Fig. 15 String read, waveform chart

2.3. Integration of the Proteus and LabVIEW Diagrams

Once the integration of the components in Proteus and the interface in LabVIEW was completed, the integration of both software was completed, and the required Domotic system was achieved (see Figura 16). Also, proceeded to create the architecture of the SubVI in LabVIEW (see Figura 17).

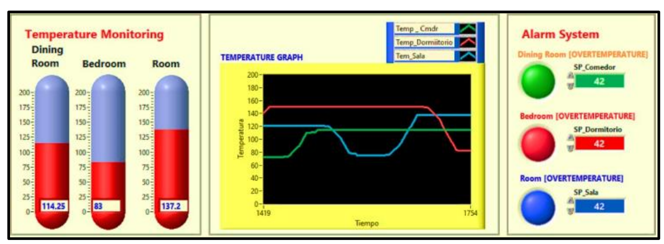


Fig. 16 Proteus integration with the LabVIEW interface

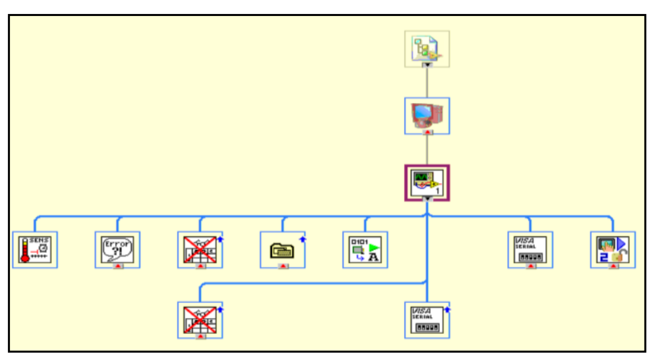


Fig. 17 Architecture of the SubVI of the domotic design

Figure 18 shows one of the SubVI of the Domotic Design.

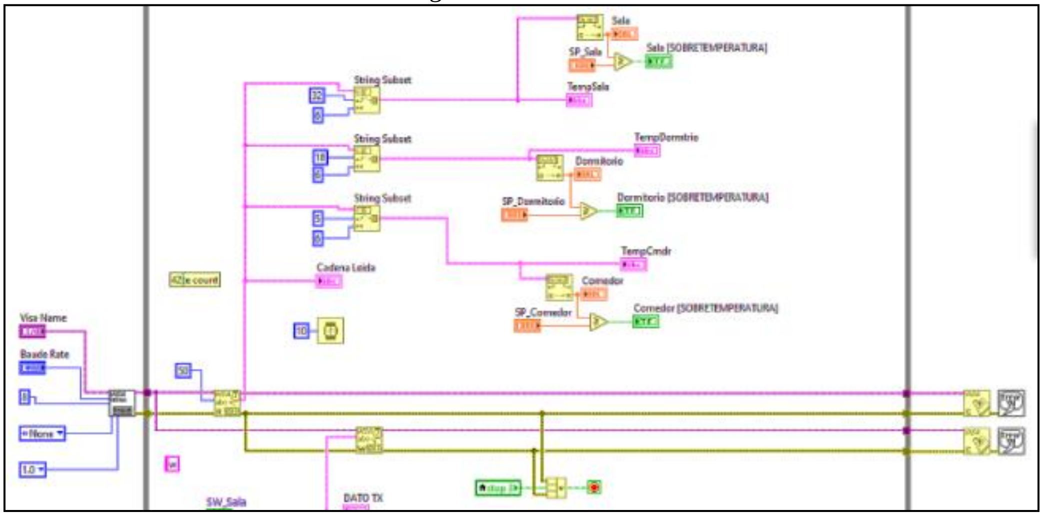


Fig. 18 Communication - Serial for acquisition

Figure 19 shows the flow diagram to be considered for the design of the Domotic system.

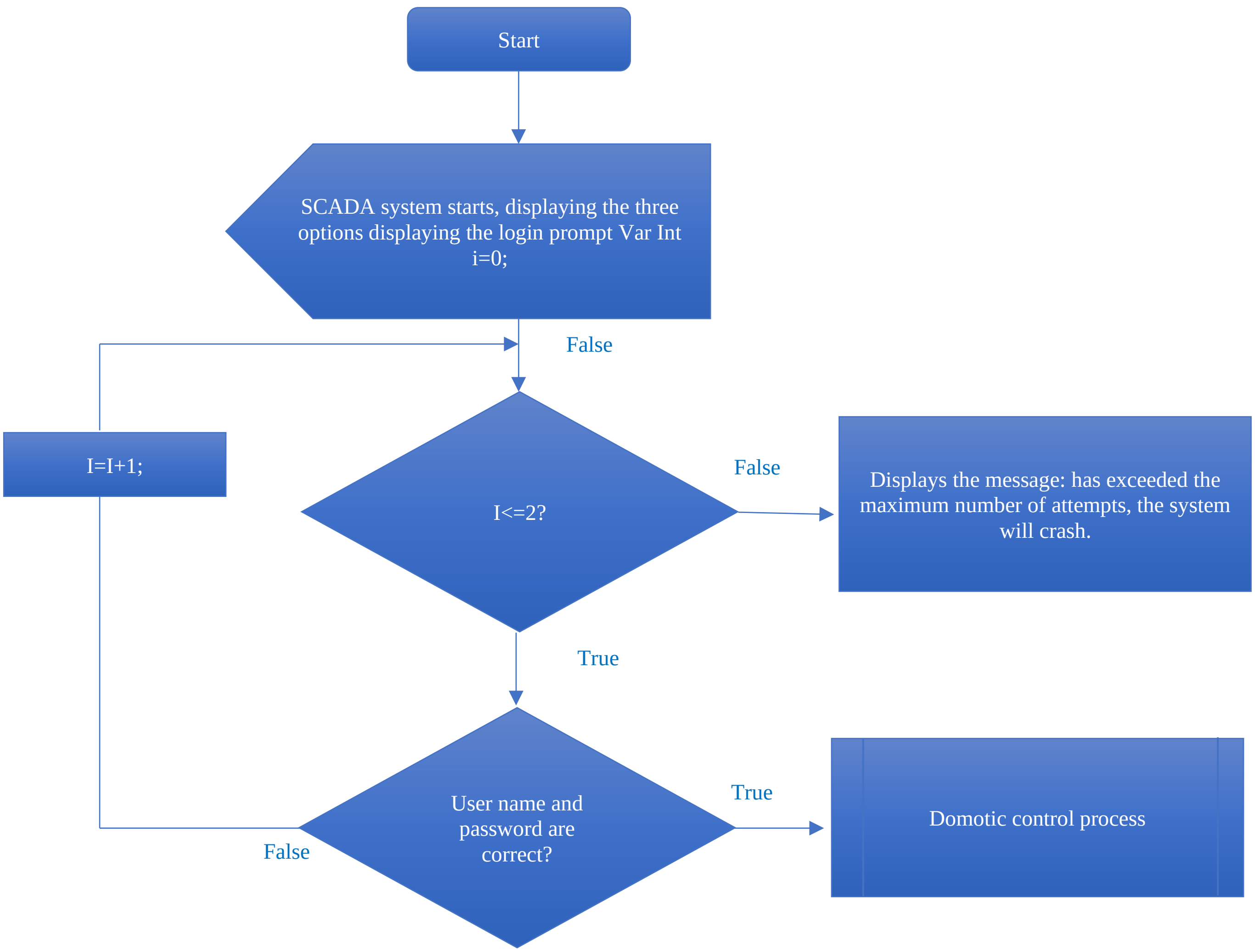


Fig. 19 General operating diagram of the domotic system

3. Results

This research presents the simulation of the results obtained.

3.1. Home Automation System Operation

3.1.1. Analog Data Recording Switch and Temperature Variation Trend

This switch controls the recording of analog temperature data in a database (Excel file named ADQ_Sensores.xls) that records the hour and minutes corresponding to the trends observed in the living room, dining room, and bedroom.

The system starts recording when the switch is ON and ends when it returns to OFF (see Figure 20 and Figure 21).

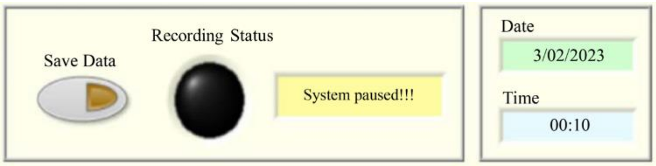


Fig. 20 Recording status interface, date and time

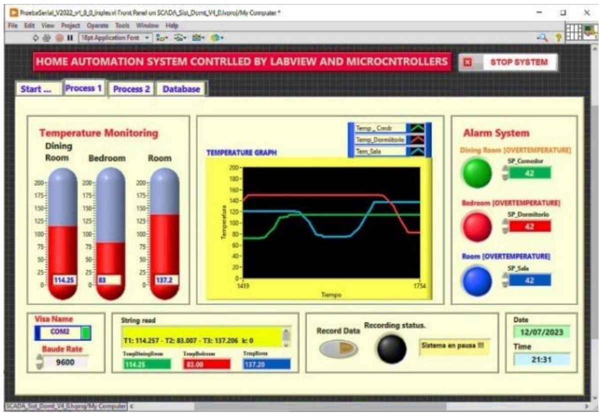


Fig. 21 Simulation in the LabVIEW interface

3.1.2. Comparison of the LabVIEW interface and the Excel Report

As shown in Figure 22, the similarity between the diagrams obtained in Excel and LabVIEW can be seen, demonstrating the effective use of the proposed design. This consistency between the graphical representations validates the successful implementation of the system and supports the coherence between the two platforms used.

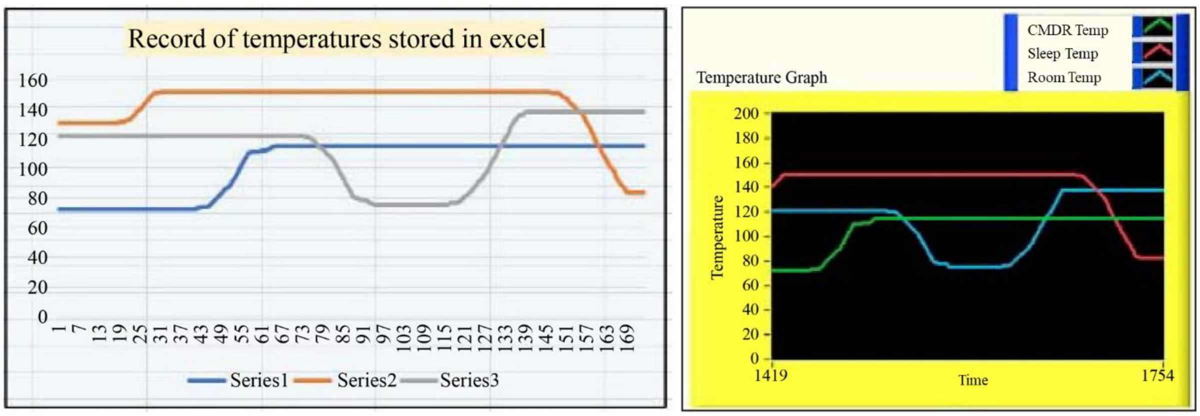
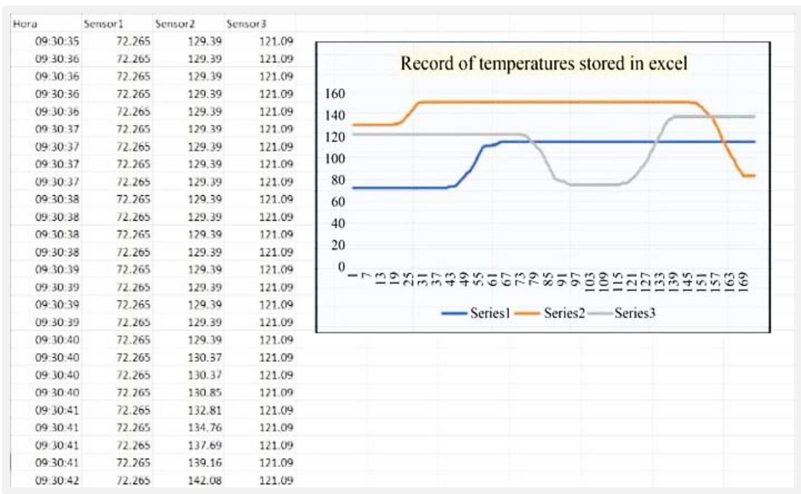


Fig. 22 Comparison of the LabVIEW interface and the excel report



Hora	Sensor1	Sensor2	Sensor3
09:30:35	72.265	129.39	121.09
09:30:36	72.265	129.39	121.09
09:30:36	72.265	129.39	121.09
09:30:36	72.265	129.39	121.09
09:30:36	72.265	129.39	121.09
09:30:37	72.265	129.39	121.09
09:30:37	72.265	129.39	121.09
09:30:37	72.265	129.39	121.09
09:30:37	72.265	129.39	121.09
09:30:38	72.265	129.39	121.09
09:30:38	72.265	129.39	121.09
09:30:38	72.265	129.39	121.09
09:30:38	72.265	129.39	121.09
09:30:39	72.265	129.39	121.09
09:30:39	72.265	129.39	121.09
09:30:39	72.265	129.39	121.09
09:30:39	72.265	129.39	121.09
09:30:40	72.265	129.39	121.09
09:30:40	72.265	130.37	121.09
09:30:40	72.265	130.37	121.09
09:30:40	72.265	130.85	121.09
09:30:41	72.265	132.81	121.09
09:30:41	72.265	134.76	121.09
09:30:41	72.265	137.69	121.09
09:30:41	72.265	139.16	121.09
09:30:42	72.265	142.08	121.09

Fig. 23 Report in excel and graph

3.1.3. Excel Report

Figure 23 illustrates how the Excel report provides detailed information on the temperatures of the different residence rooms obtained through the sensors. This report is a useful tool that provides a complete and accurate analysis of the temperature data recorded in each specific area of the house.

4. Discussion

The experimental results demonstrate the correct control of lamps and loads and the accurate acquisition of analog data to measure the temperature of different residence environments. In addition, the data storage function was implemented in an Excel file, all controlled from the SCDA developed in LabVIEW and microcontrollers. This work represents a proof of concept of a highly scalable system for implementation in any residence, even with multiple floors, rooms, and diverse analog variables. It also considers the incorporation of alarms and centralized control, as well as local control on each floor, with the option of mobile application and the use of Internet protocols to increase the system's stability, aspects that will be the subject of future research.

5. Conclusion

The objective of this research was to analyze the impacts derived from the development of a domotic system using LabVIEW engineering software and the PIC 16F8877A microcontroller. The research has concluded that using LabVIEW software is an excellent alternative to create high-impact graphical interfaces in domotic systems. In addition, it has been proven that this technology allows the development of reliable and low-cost home automation systems. LabVIEW's embedded system programming and user-friendly graphical interface facilitate harmonious interaction with the user. Using structured programming and propagation nodes like Sub vit is indispensable in in-home automation systems. Also, incorporating microcontrollers in these projects provides greater control over the other electronic components. This study supports the feasibility and benefits of using LabVIEW and microcontrollers in developing efficient and functional home automation systems.

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