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System for access control to a shopping mall

Sistema para el control de acceso a un centro comercial

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Sequential logic systems over the years have allowed an improvement in control and access systems. This article looks for a way to use this type of logic to create an autonomous system in Verilog for the access of people to a shopping mall, which should allow the realization of counts, movement analysis, and temperature detections, which allow avoiding the direct relationship with the security employees, making this way a protection measure for situations like the one that is currently being experienced with the global pandemic. This system, due to its configuration and accessibility, must be easy to understand, therefore the operation of this project is visualized with a traffic light configuration where green represents a positive action of entry, represents an alert or emergency. The system will give a stop signal, either for high temperatures or for people over or equal to the limits.

Keywords: Access control, control system, sequential logic, traffic light

Los sistemas de lógica secuencial a lo largo de los años han permitido un mejoramiento en los sistemas de control y de acceso. Este artículo busca la manera de usar este tipo de lógica para crear un sistema autónomo en Verilog de acceso de personas a un centro comercial, el cual debe permitir la realización de conteos, análisis de movimiento y detecciones de temperatura, que permitan evitar la relación directa con los empleados de seguridad haciendo de esta forma una medida de protección para situaciones como la que se está viviendo actualmente con la pandemia mundial. Este sistema, debido a su configuración y accesibilidad, debe ser de fácil comprensión, por esto el funcionamiento de este proyecto se visualiza con una configuración de semáforo en donde el verde representa una acción positiva de ingreso, mientras que el rojo representa una alerta o emergencia. El sistema dará una señal de alto, ya sea por altas temperaturas o por aforo de personas que sobrepase o iguale los limites.

Palabras clave: Control de acceso, lógica secuencial, semáforo, sistema de control

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Introduction

Over the years, technology and its implementation in security systems and access controls for shopping malls have improved significantly, due to the need to control the flow of people entering and leaving the mall, such controls have different purposes such as identification of workers, recognition of unauthorized personnel, early detection of threats among other problems or situations that may occur in places with high crowds of people (Cardona & Botero, 2017).

Currently, the access control systems of people have been forced to improve, but in general, are limited by motion sensors that only open and close their doors, this system is functional, but in terms of management and identification is obsolete, as it does not allow to have control of people entering the mall (Martínez et al., 2012). Due to the situation that the world is going through nowadays, it has become necessary to improve this type of system, since they must have control of the flow, quantity, and temperature of the users (Guerrero et al., 2017).

At this time the COVID-19 pandemic has changed the operation of the entrance to shopping centers, since the agglomeration of people in such places daily is quite frequent, one of the solutions that have been implemented are the manual temperature measurements, and controlled entry by security personnel, this process besides being inefficient, is unsafe for staff, as it exposes them to greater contact and exposure to the virus (Fernandez, 2019).

In this article we want to provide a solution to these problems through a system that allows us to quantify and control the entry of people, enabling entry and exit doors through motion and temperature sensors, these sensors allow us to know the number of people who are inside the mall, ensuring a maximum quota of people and the time that these individuals will last in the facilities, Taking into consideration that users can only enter to make purchases and specific transactions, this time will be better controlled with the system, in addition, the temperature sensor will allow making a selection of people who can enter, since high-temperature levels are one of the main symptoms generated by the COVID-19 virus (López et al., 2019).

The implementation of the system will be developed using the Verilog language, to codify the whole system and its behavior, since it allows complete control of the software and hardware, making the design of the circuits and logical combinations more optimal and efficient (Martínez & Castiblanco, 2011; Pardo, 2015).

The behavior of the system is similar to that of a traffic light since it is based on the same principle: when the number of people inside the shopping center is less than or equal to 100, the green signal will light up; if the temperature of any of the individuals entering is higher than allowed, an emergency signal will appear, represented by the color red, and so on with the different representations that will be used for the different situations (Galvis et al., 2011).

Problem Formulation

The world is currently undergoing abrupt changes due to the COVID-19 pandemic since existing medical advances are limited to controlling a problem of this nature, therefore, efforts to create a preventive vaccine against this virus have multiplied, despite this, the development of such vaccine has been advancing slowly, so so far the only option we have is to be prevented and protect ourselves by changing the way we live, think and relate to each other (Cooper & Stowe, 2018).

The COVID-19 virus is transmitted quickly and easily between people, it is only enough to come into contact with air that has attached particles of the virus to become infected (Diaz & Mendez, 2019), for the moment social distancing is one of the most effective ways to avoid contagion since it allows separating people who may be carriers of the virus and who do not know it from healthy people (Penaranda & José, 2016), for this reason, many places with possible agglomerations have had to close their doors causing millionaire losses, one of these places are shopping malls. Shopping malls apart from being a meeting place where you can interact, socialize and meet the needs of leisure and entertainment, are now places that offer various services that can be considered of vital importance to people, such as banks, pharmacies, supermarkets among others, for this reason, it was necessary to find a solution so that people can access the malls without exposing themselves to a possible contagion.

Shopping malls have opted for not very efficient methods that put the lives of their employees at risk, in addition to this there is no relevant control of the number of people entering and leaving the establishment (Martínez & Castiblanco, 2010). In the present article an autonomous system is designed that allows to have access controls for a shopping center, this consists of three enabled entrance doors and one exit door, in the entrances there are three sensors that detect when the person enters, in addition these three sensors detect the body temperature, when the person enters the shopping center the sensors deliver a logical 1, In this way, if there are more than 100 people inside the mall, a red light will turn on and no more people will be allowed to enter, otherwise the light will be green and one person will be allowed to enter every 30 seconds, the temperature sensors in each door will give a logical 0 if the person's temperature is lower than 37.6 degrees, otherwise the sensor will deliver a logical 1 that will activate an emergency signal and a red light, at the exit a sensor delivers a logical 1 when it detects the exit of a person otherwise a logical 0, with this autonomous system guarantees a certain number of people inside the mall thus allowing social distancing, it also ensures that people entering the mall do not have one of the main symptoms of

COVID-19 (Pencue et al., 2015). Although the principle of operation is based on simple sensors, its design is efficient, inexpensive and easy to implement.

The rest of this paper is structured as follows. Section 2 presents the general formulation of the problem addressed. Section 3 details the design methodology, including the modules and the Verilog code used. Section 4 presents the behavior utilizing simulation, and finally, in the last section, we present the conclusions.

Research Method

The design to be carried out in this project is intended to be an autonomous system in Verilog language for the control of access to people to a shopping center, for this purpose the procedure and methodology presented below should be implemented (Escobar et al., 2008).

1. The inputs and outputs of the shopping center are determined to know which components will be used in the Verilog coding.

2. Sensors S.IG1, S.IG2, S.IG3, and the infrared thermal sensor will be located at all entrance doors, and the S.OG1 sensor at the exit door. In addition, security and surveillance personnel must be available to keep the flow of people controlled in one direction only.

3. The code thought to realize this system starts with a first filter consisting of an infrared thermal sensor, which when detecting a temperature lower than 37.6 degrees centigrade the sensor will deliver a logic code 10 which will turn on a green light (OKG1, OKG2, or OKG3) to allow entry, otherwise the sensor will deliver a logic code 01 which will activate an emergency signal at the corresponding door (red light OEG1, OEG2 or OEG3).

4. After the first filter, at the inputs (IG1, IG2, and IG3) there will be sensors S.IG1, S.IG2, and S.IG3 that will deliver a logical code 1 when the person enters, these signals will reach a module that we will call counter, which will turn on a red light when the number of logical 1's representing the entry of each person is 100, otherwise, it will turn on a green light 4 seconds every 30 seconds, at the exit door OG1 there is the sensor S.OG1 delivers a logic one when a person passes through it, indicating in any of the inputs IG1, IG2, and IG3 that another person can enter.

Access and counting module

A module is created for each door that allows access to people who do not have a temperature higher than 37 degrees Celsius, it also allows counting the number of people entering through each door, as the modules for the three entrance doors work in the same way only the operation of the first module will be described (Figs. 1, 2, and 3).

The access and counting module has two inputs called SensorMov and SensoTemp, when the SensorMov detects a person it sends a logical 1 to the system, and the SensorTemp measures the body temperature of the person who was detected by the SensorMov, if it is higher than 37 degrees Celsius an emergency signal is activated which we call SalidaR, which will show a logical 01 indicating the alert and thus denying the entrance to the Mall, otherwise the OutputV will be activated and will show a logical 10 indicating that the person can enter when this condition is met, the person will be counted as entering the Mall.

Final adder module

A module is created in which information is received on how many people have entered the mall through the three entrance doors and how many people have left through a single exit door, in order to constantly count the number of people inside the mall, so that in no way the number of people inside the mall exceeds 100 people.

The final summing module has four inputs Entr1, Entra2, Entr3 and SensorS, the first three inputs are responsible for entering the module the number of people who have entered the mall for each of the three doors, in this way the module will add the total number of people who have entered the mall, also subtract one person to the total of the previous sum, when the movement sensor at the exit of the mall detects that a person has left, if the total number of people inside the mall is between zero and 100, the SV exit will be activated, which will indicate at the doors one, two and three, that access to the mall is still allowed, otherwise the SR exit will be activated, which will indicate at the three entrance doors that the mall will no longer allow access to the mall (Figs. 4, 5, 6, and 7).

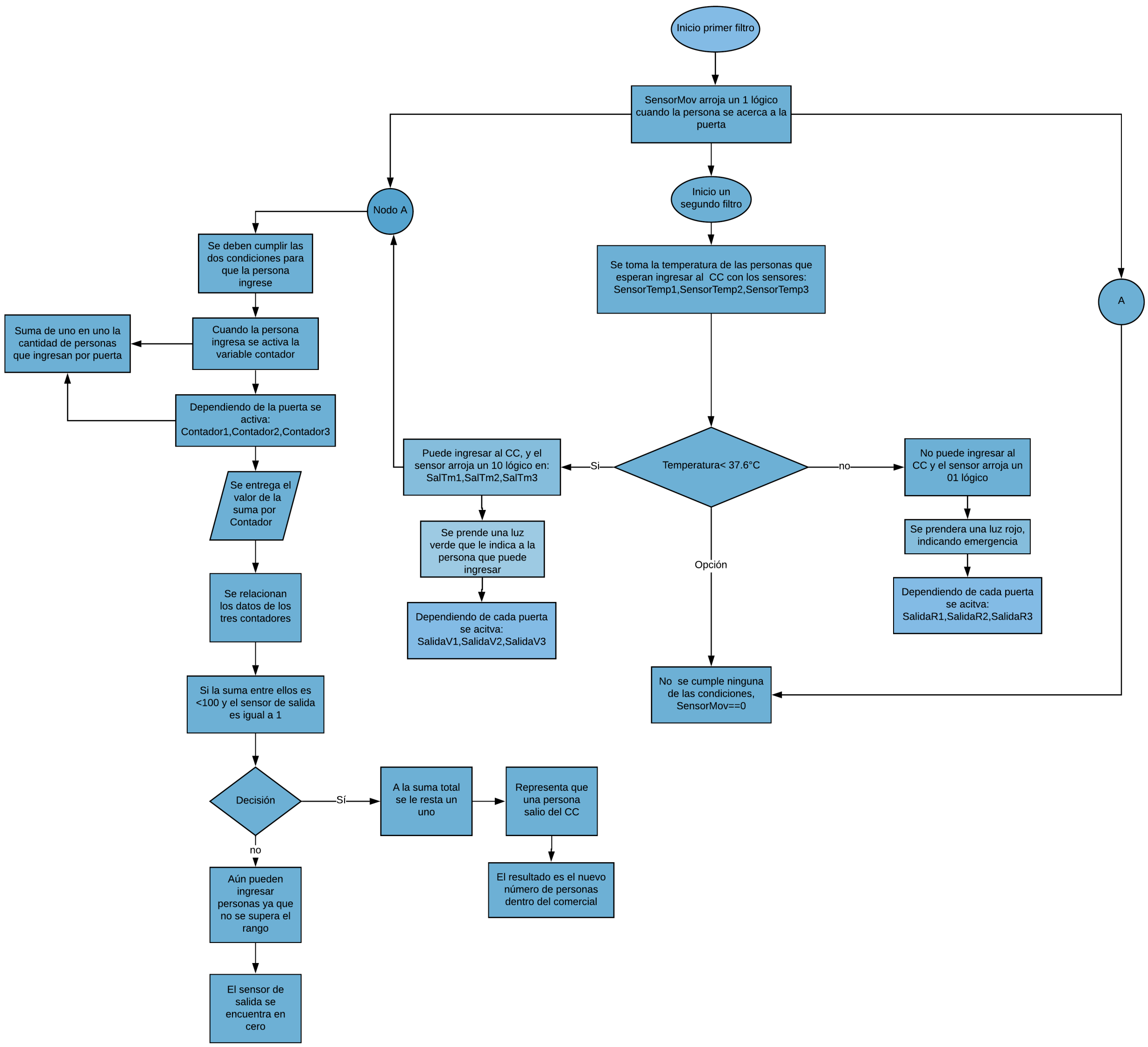
Results and Discussion

The results obtained in the simulations are presented in Fig. 8 and Fig. 9. As part of the analysis of these simulations, the codes and their operation in the EDAplayground simulator were taken into consideration. The network used in the EDAplayground simulator is a VLSI net that transforms Boolean circuits into equations of the form ($c_j = g_i(e_{ij})$) where (c_j) represents a Boolean circuit.

The first simulation (Fig. 8) represents the result of the coding performed for door number one, which is intended to perform three actions that are related but work independently. First: detect the movement of a person outside the door, second: measure the temperature of the detected person, and third: if the conditions are met, the person will be counted as entering the mall. With these parameters and the results visualized in EDAplayground, it can be said that the designed code works correctly.

Figure 1

Flowchart.



In the simulation, to check the operation of the code, four possible cases that may occur if the system is in operation were placed, for the first case the temperature of the person was less than 37 degrees Celsius, therefore, the counter variable indicated that a person met the requirements and therefore had entered the mall, In the next two cases, as the measured temperature was also lower, only the increase in the counter and the measured value were shown; the other specifications remained constant until the change in the last case. This case showed a different condition, since the temperature measured by the sensor was 38 degrees Celsius, so it changed the other variables, turning on the alarm and taking a logical 01, with this last case the operation of the counter was checked since the conditions were not met, leaving the counter variable as it was when the conditions were true until a new case is presented.

For the second simulation (Fig. 9), the purpose was to test the operation of the last module, which was in charge of determining the total number of people inside the mall and the final total when a person exited the mall, taking into consideration that if the initial number of people was equal to 100, then no person could enter until an exit was detected, taking into account this, two possible cases were considered.

Figure 2

Block diagram.

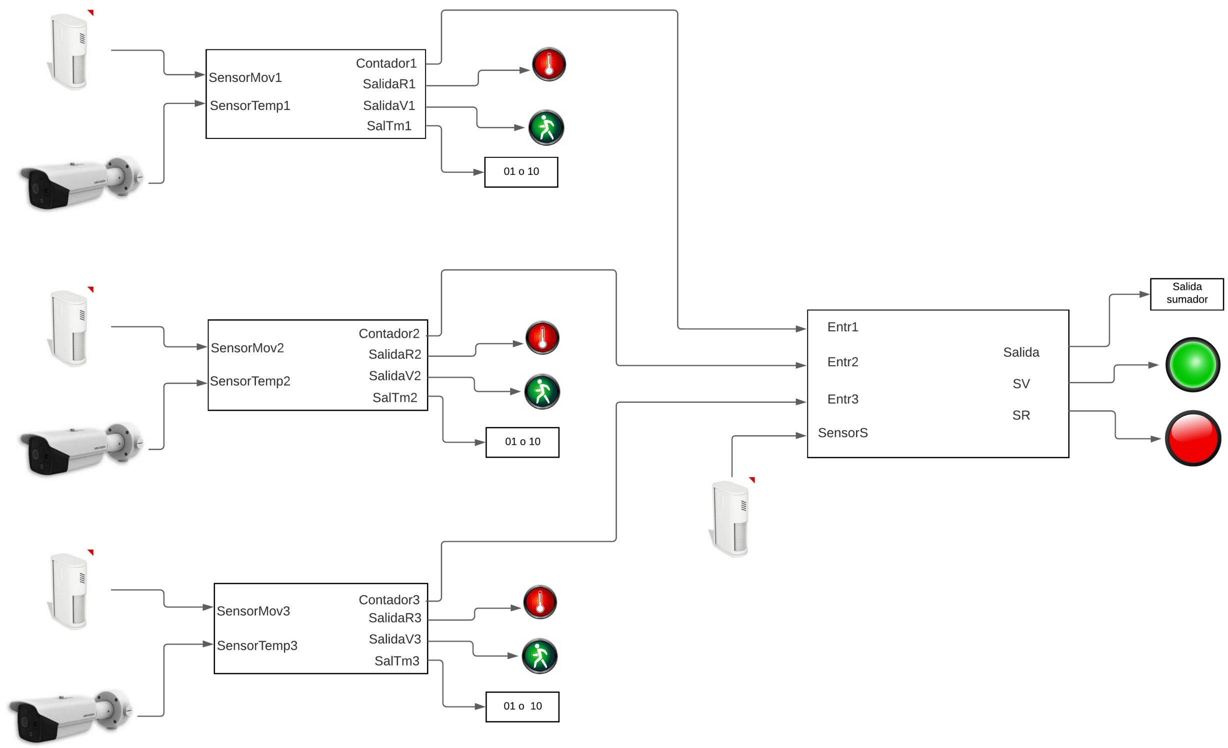


Figure 3

System modules.

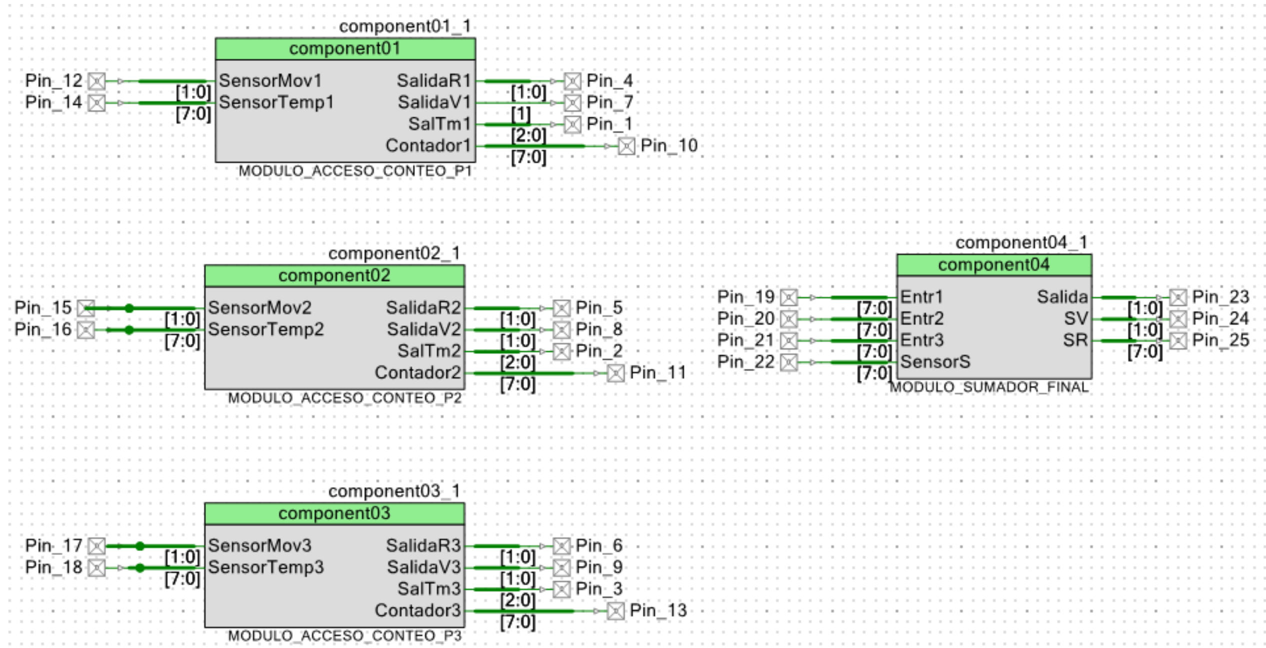


Figure 4

Code for access and counting module.

```
module component01 (
    output reg [7:0] Contador1,//Salida con el total de ingresos por persona en la puerta 1.
    output reg [1:0] SalidaR1,//Salida para luz roja de advertencia.
    output reg [2:0] SalidaV1,//Salida para luz verde indica a la persona que puede ingresar.
    output reg [2:0] SalTm1,//Salida a Dsiplay, si la persona tiene fiebre o no.
    input wire [1:0] SensorMov1, // Sensor de Movimiento.
    input wire [7:0] SensorTemp1 // Sensor de temperatura.
);
    parameter param_19 = 0;

//Indicamos que la entrada Contador inicia en estado  0.
initial Contador1=1'b0;

//`#start body` -- edit after this line, do not edit this line

//        Your code goes here

always @ (SensorMov1 or SensorTemp1)
    begin
//Condiciones para que la persona pueda o no ingresar al CC.
//Temperatura mayor a 37°C no puede ingresar al CC.
    if(SensorMov1==1)
      if(SensorTemp1>=8'b00100101)
        begin
        SalTm1=2'b01;
        SalidaR1=1;
        SalidaV1=0;
        end
//Temperatura menor a 37°C la persona puede ingresar
      else
        begin
        SalTm1=2'b10;
        SalidaR1=0;
        SalidaV1=1;
        Contador1<=Contador1+1;
        end
    else
      begin
      SalTm1=1'b0;
      SalidaR1=0;
      SalidaV1=0;
      end
    end

//`#end` -- edit above this line, do not edit this line
endmodule
```

Conclusion

As a consequence of what has been exposed in the present article, it has been possible to determine that the sequential systems help to give solutions to the diverse problems that can be presented in difficult times. For this reason, it is of great utility to expose the forms of management, development, and control that can have a common digital system, which can be implemented in situations in which quantity or veracity controls are needed. In an introduction that can be seen as one of the central themes of our article, we have exposed the elements in which management, development, and control have a common system that can be implemented in situations where quantity or veracity controls are needed.

Similarly, we believe it is important to note that the functions represented by the traffic light configuration, and by the movement and temperature modules can be very useful, not only for access control but also for systems

Figure 5

Code for total adder module.

```
module component04 (
    output reg [7:0] Salida,//Indica el total de las entradas 1, 2 y 3.
    output reg [1:0] SR,    //Indica que hay menos de 100 personas en el CC.
    output reg [1:0] SV,    //Indica que hay 100 personas en el CC.
    input wire[7:0] Entr1,  //Indica el total de ingresos por la puerta 1.
    input wire[7:0] Entr2,  //Indica el total de ingresos por la puerta 2.
    input wire[7:0] Entr3,  //Indica el total de ingresos por la puerta 1.
    input wire[1:0] SensorS //Indica la salida de una persona por la puerta de salida.
);
    parameter param_19 = 0;

initial Salida=1'b0;

//`#start body` -- edit after this line, do not edit this line

//        Your code goes here
always @ (Entr1 or Entr2 or Entr3 or SensorS)
//Si en el CC hay menos de 100 personas y el sensor de salida indica
//una salida, sumar el total de puerta 1, 2 y 3 y restar una salida.
    if(8'b00000000<Salida<8'b01100100 && SensorS==1'b1)
        begin
        Salida=Entr1+Entr2+Entr3;
        Salida=Salida-SensorS;
        SV=1;
        SR=0;
        end
    else
        begin
        SR=1;
        SV=0;
        end

//`#end` -- edit above this line, do not edit this line
endmodule
//`#start footer` -- edit after this line, do not edit this line
```

that need to control the flow of people depending on special parameters, therefore, with this coding we can relate the independent variables with dependent factors of other behaviors, at the end of it the results can be as for the present case mostly positive. The purpose of traffic signals is to manage the flow of people.

In general, the applications for sequential and combinational systems can have a diversity of functions, therefore, the advances made with these systems must be presented and worked correctly, since they can be used as the basis for more complex programs and developments. It is because of its diversity and complexity that the most advanced applications of sequential systems are now being applied to, among other things, air traffic control systems, communication networks, and military command-and-control.

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Figure 6

Simulation code access and counting module.

```
//testbench.sv
module Prueba;
  reg [1:0] SensorMov1;
  reg [7:0] SensorTemp1;
  wire [7:0] Contador1;
  wire [1:0] SalidaR1;
  wire [2:0] SalidaV1;
  wire [2:0] SalTm1;

  component01
Modulo_Puerta_1(SalidaR1,SalidaV1,SalTm1,Contador1,SensorMov1,SensorTemp1);

    initial begin
      $dumpfile("dump.vcd");
      $dumpvars(1,Prueba);

      SensorMov1=1'b0;
      SensorTemp1=8'b00000000;

     SensorMov1=1'b1;
     SensorTemp1=8'b00100100;
     #1

     SensorMov1=1'b1;
     SensorTemp1=8'b00100010;
     #1

     SensorMov1=1'b1;
     SensorTemp1=8'b00100001;
     #1

     SensorMov1=1'b1;
     SensorTemp1=8'b00100110;
     #1
      $finish;
    end

endmodule
```

```
//Desing.sv
module component01 (
  output reg [1:0] SalidaR1,
  output reg [2:0] SalidaV1,
  output reg [2:0] SalTm1,
  output reg [7:0] Contador1,
  input wire [1:0] SensorMov1,
  input wire [7:0] SensorTemp1
);
    parameter param_19 = 0;

initial Contador1=1'b0;
//        Your code goes here
  always @ (SensorMov1 or SensorTemp1)
    begin
    if(SensorMov1==1)
      if(SensorTemp1>=8'b00100101)
        begin
        SalTm1=2'b01;
        SalidaR1=1;
        SalidaV1=0;
        end
      else
        begin
        SalTm1=2'b10;
        SalidaR1=0;
        SalidaV1=1;
        Contador1<=Contador1+1;
        end
    else
      begin
      SalTm1=1'b0;
      SalidaR1=0;
      SalidaV1=0;
      end
    end
//`#end` -- edit above this line, do not edit this line
endmodule
```

Figure 7

Simulation code final adder module.

```
//testbench.sv
module Prueba;

  wire [7:0] Salida;
  wire [1:0] SV;
  wire [1:0] SR;
  reg [7:0] Entr1;
  reg [7:0] Entr2;
  reg [7:0] Entr3;
  reg [1:0] SensorS;

  component04 Modulo_Contador(Salida,SV,SR,Entr1,Entr2,Entr3,SensorS);

    initial begin
      $dumpfile("dump.vcd");
      $dumpvars(1,Prueba);

      Entr1=8'b00000000;
      Entr2=8'b00000000;
      Entr3=8'b00000000;
      SensorS=1'b0;

      Entr1=8'b00010100;
      Entr2=8'b00001010;
      Entr3=8'b00001111;
      SensorS=1'b1;
      #1

      Entr1=8'b01000001;
      Entr2=8'b00001010;
      Entr3=8'b00001111;
      SensorS=1'b0;
      #1

      $finish;

    end
endmodule
```

```
//Desing.sv
module component04 (
  output reg [7:0] Salida,
  output reg [1:0] SV,
  output reg [1:0] SR,
  input wire [7:0] Entr1,
  input wire [7:0] Entr2,
  input wire [7:0] Entr3,
  input wire [1:0] SensorS
);
    parameter param_19 = 0;

initial Salida=1'b0;

//        Your code goes here

  always @ (Entr1 or Entr2 or Entr3 or SensorS)
    if(8'b00000000<Salida<8'b01100100 && SensorS==1'b1)
    begin
    Salida=Entr1+Entr2+Entr3;
    Salida=Salida-SensorS;
    SV=1;
    SR=0;
    end
  else
    begin
      SR=1;
      SV=0;
    end

endmodule
```

Figure 8

Simulation Module 1 (Puerta1).

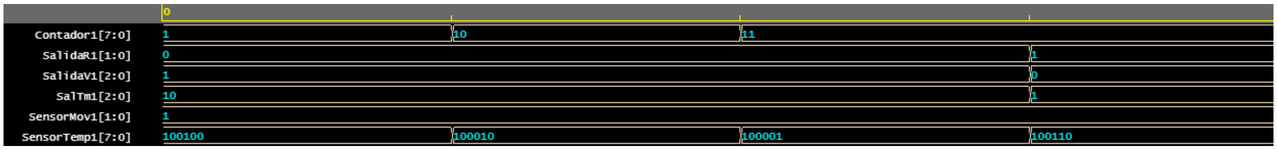
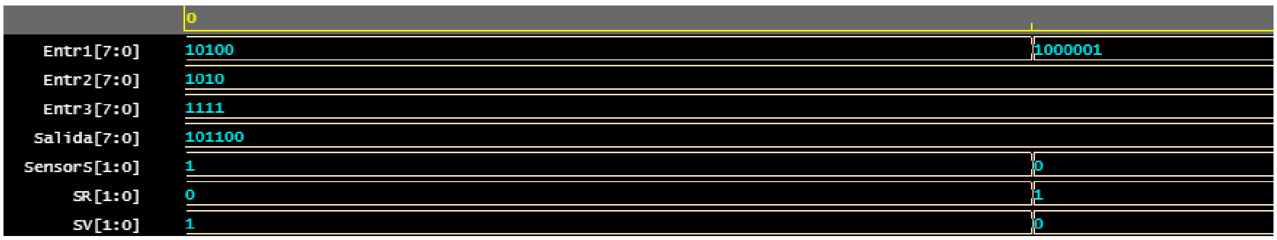


Figure 9

Simulation Module 4 (Contador).



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