DESIGN AND SIMULATION OF HOME ALARM SYSTEM USING VERILOG

A PROJECT REPORT

Submitted by

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in partial fulfillment for the award of the degree

of

BACHELOR OF DEGREE

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

PSG INSTITUTE OF TECHNOLOGY AND APPLIED RESEARCH

COIMBATORE - 641062

ANNA UNIVERSITY: CHENNAI 600 025

MARCH 2021

BONA FIDE CERTIFICATE

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INTERNAL EXAMINER

EXTERNAL EXAMINER

ABSTRACT

With the increasing number of burglar incidents, there has been a focus on the development of home security systems. Traditional security systems have only been concerned about gathering evidence against trespassing. Advancements in technology have not only helped monitor but also alert the homeowner instantly in the event of any breach. The aim of this project work is to design and simulate a secure home alarm system using Verilog. Various entry points of the house will be monitored and an alarm will be raised when someone trespasses.

ACKNOWLEDGEMENT

It is our privilege to express our deep sense of gratitude towards all those who gave us the possibility to complete this thesis.

We express our profound sense of gratitude and regards to our Principal **DR. G. CHANDRAMOHAN** for giving all facilities to do the project as well as to complete this project.

We are deeply indebted to **DR. C. L. VASU**, Professor and Head of the Department, Electrical and Electronics Engineering, for his valuable suggestions.

We would like to express our deep sense of respectful gratitude to our guide,

DR. C. L. VASU, Professor, Department of Electrical and Electronics Engineering for his persistent encouragement and assistance at each and every juncture of our project work for successful completion of this project.

We thank all the faculty and staff members of the Department of Electrical and Electronics Engineering for their help during the project work.

Finally, we express our deep sense of gratitude to my parents, friends and all others who were indirectly involved with this project for their invaluable help.

The technical information derived from various research papers is gratefully acknowledged.

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CHAPTER-1

INTRODUCTION

1.1 VERILOG

Verilog, standardized as IEEE 1364, is a hardware description language (HDL) used to model electronic systems. It is most commonly used in the design and verification of digital circuits at the register-transfer level of abstraction. It is also used in the verification of analog circuits and mixed-signal circuits, as well as in the design of genetic circuits

Some of the popular examples of Verilog are Odd Parity Generator, Pulse Generator, Priority Encoder, Behavioral Model for 16 words, 8bit RAM, etc.

1.2 VERILOG FEATURES

i) Sequential and concurrent activities.

ii) Design exchange

iii) Standardization

iv) Documentation

v) Readability

vi) Large-scale design

vii) A wide range of descriptive capability

1.3 HOME SECURITY SYSTEM

Home security system literally means something is secured through a system of interworking components and devices.

A home security system includes networks of integrated electronic devices working together with a central control panel to protect against burglars and other potential home intruders.

A typical home security system includes:

i) A control panel, which is the primary controller of a home security system
ii) Door and window sensors
iii) Motion sensors, both interior and exterior
iv) Wired or wireless security cameras
v) A high-decibel siren or alarm
vi)A yard sign and window stickers

1.4 NEED FOR THE PROJECT

1.4.1 Home alarm systems deter criminal activity

To put it simply, the mere presence of a home security system will deter many perpetrators from doing criminal acts. They do not want to increase the chances they will get caught by the homeowner or by the police in the act. And if they see or suspect security cameras, the chances of them doing the crime decrease even further.

1.4.2 Home alarm systems protect property and valuables

A home security system is a first line of defense for keeping your property and valuables safe. Vandals are less likely to do damage to your property if there is a chance of being caught. An alarm system can alert police if something bad is going down, which keeps both your property and your valuables safer.

1.4.3 Home alarm systems allow remote viewing/access to your house

Modern home security systems offer the homeowner the ability to see what is going on using smart devices. They can alert if someone comes into the home, like a child after school lets out. The homeowner can also arm and disarm the system remotely. If security cameras are installed, along with the home security system, the homeowner can also get a view of who is around the house.

1.4.4 Home alarm systems lower homeowner's and renter's insurance

Insurance companies do not like risk. If you have a home security system, you are at a lower risk of having a theft or burglary. Insurance companies will lower your homeowners' insurance rates because of this decreased risk of incurring a loss. This is particularly enticing for recent buyers of homes hoping to cut back on costs. The financial implications of home loans can leave you feeling quite restricted. That is why any possibility of reducing insurance costs should be welcomed.

1.4.5 Home alarm systems help protect your home from intruders

Home security systems can alert if someone comes into the home without permission. The monitoring service can get emergency personnel on the way. Most systems come with panic features that allow someone at home to send an emergency signal if someone tries to come in when the alarm system is not armed.

1.5 PROPOSED SYSTEM

To realize an actual home alarm system, the windows and doors are represented by proximity sensors. The proximity sensor provides an output of logic 0 if someone goes in front of it. Additionally, a movement sensor (PIR) is also provided. The movement sensor gives an output of logic 1 when it senses movement. There is also an on/off switch for the alarm which gives logic level 1 when activated. Based on these constraints, the logic function will be

$$A = (S_0 + S_1 + S_2 + S_3 + PIR).m$$

The IDE that will be used for this design is Vivado Design Suite.
Basys 3 development board is considered for simulation.

CHAPTER 2

LITERATURE REVIEW

2.1 SENSOR BASED APPROACH

The conventional design of home security systems typically monitors only property and lacks physical control aspects of the house itself. Also, the term security is not well defined because there is a time delay between the alarm system going on and actual arrival of the security personnel. This project work presents the design and implementation details of this new home control and security system based on field programmable gate array (FPGA). The user can interact directly with the system through a web-based interface over the Internet and home appliances such as air conditioners, lights, door locks and gates are remotely controlled through a user-friendly web page. In addition, the work done in this project enhances the security aspect of the system by its capability of monitoring entry points such as doors and windows so that in the event of any breach, an alerting email message is sent to the homeowner instantly. Webpage approach has been preferred over a customized graphical user interface (GUI)

2.2 USING BASYS 3 KIT

As FPGAs have grown in vast capability to security. It has various applications such as digital cinema, security system and encryption. Here, when any trespasser enters the area under surveillance, and the security system is active, the sensor detects the motion of a person with the infrared radiations emitted from the human body. The sensor, as a result, sends the signal to the FPGA

kit, which further enables the GSM module to send SMS to the mobile number that is programmed into the kit through the program. The algorithm is coded in Verilog and is simulated using Xilinx software. Although successfully implemented, due to the usage of GSM transmission, the implementation can encounter interference occasionally.

2.3 IOT BASED APPROACH

The main aim is to make our homes smarter and more secured. The technology or concept involved here is basically IOT and cloud-based services which are a technology of present and future. Home automation systems have achieved much more popularity in the past decades and have focused on mainly improving quality of life overall. The IOT based devices will help in surveillance and energy management and also provide support for a direct message or SMS to nearby friends and support with GPS location and predefined message just by a single tap by the user. All these operations are controlled by a cloud system with active internet support. Dependency on professionals, cost, security and privacy issues

2.4 NFC TAG

All over the world, security has been a major concern in every home. Automated security systems are a useful addition to today's home where safety is an important issue. Vision-based security systems have the advantage of being easy to set up, inexpensive and non-obtrusive. Here, a security system has been developed that uses sensors to detect any security violation and sends out the alert signal by high intensity Buzzer.

Three levels of security are implemented in this project work - NFC tag, Password and PIR motion sensor. To open the door a person should provide an NFC tag and password. If one of them is absent the door will not open. The door will be opened by a servo motor with a lock coupled in its shaft. When the wrong password is pressed, error text is displayed in the LCD. When an authorized person leaves the door, he has to show his tag in the reader. Otherwise, the door will not close. Now if an unwanted man enters the room by password breaking or without NFC the PIR sensor works. It sounds the buzzer. So, maximum security will be maintained at home. This security can be applied not only at home but also the place where important document files are preserved and also the bank vault.

2.5 LED and LDR

The liquid crystal display (LCD) is used as a user interface. Each one of the four walls has a light beam (transmitter) and light dependent resistor (receiver) the light beam is pointing at the light dependent resistor (receiver) the system also has a real-time clock that use to save the time of when last a particular wall crossed and can be view by the user when pressing the view mode button. When the system is powered on, it displays on the liquid crystal display (LCD) 'ALL 4 WALLS OK' and the motor that is rotating the CCTV camera is by default located at the north wall. Whenever a wall (say east wall) is crossed by an intruder the system will alert the user (through buzzer) and display on the liquid crystal display (LCD) 'EAST WALL CROSSED' the system will also save the time at which the east-wall was crossed and will automatically control the motor to rotate and stay at east-wall in order to capture the real-time video of the area using a closed-circuit television (CCTV) camera that is mounted on the motor. The system will remain at the east wall and keeps alarming the user with the help of buzzer until another wall is crossed at the same time if all the walls are crossed it will still notify the house owner by displaying on the LCD the amount of the walls crossed.

2.6 IMPROVING HOME SECURITY SYSTEM

This chapter explains the various security issues in the existing home automation systems and proposes the use of logic-based security algorithms to improve home security. The work classifies natural access points to a home as primary and secondary access points depending on their use. Logic based sensing is implemented by identifying normal user behavior at these access points and requesting user verification when necessary. User position is also considered when various access points change states. Moreover, the algorithm also verifies the legitimacy of a fire alarm by measuring the change in temperature, humidity and carbon monoxide levels, thus defending against manipulative attackers. In the experiment the proposed logical sensing algorithm was successfully implemented for a month in a studio apartment. During the course of the experiment the algorithm was able to detect all the state changes of the primary and secondary access points and also successfully verified user identity 55 times generating 14 warnings and 5 alarm

CHAPTER 3

FUNDAMENTALS

3.1 FPGA

FPGA (Field Programmable Gate Array) offers a series of security features for configuration and operation. A field-programmable gate array (FPGA) is a type of integrated circuit (IC) that can be programmed in the field after its been manufactured for the convenience of the user. An FPGA is similar to a PROM (Programmable Read-Only Memory), but it has more features and is more versatile.

FPGA has the following advantages over microcontrollers:

• Extremely adaptable

• Reconfigurable Processing in parallel

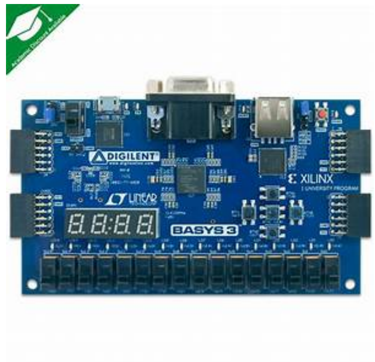
• An FPGA is more expensive than a microprocessor or an ASIC, but it can be reprogrammed to perform different tasks repeatedly.

• Extremely cost-effective due to the elimination of recurring expenses.

• The FPGA has a much simpler design cycle to manage.

• It requires less manual intervention.

The Basys 3 is an entry-level FPGA development board designed exclusively for the Vivado Design Suite featuring the Xilinx Artix-7-FPGA architecture. Basys 3 is the newest addition to the popular Basys line of FPGA development boards for students or beginners just getting started with FPGA technology.



3.2 PIR sensor:

A PIR sensor detects variations in the amount of infrared radiation impinging on it from any emitting source, which varies depending on the temperature and surface characteristics of the objects it detects. When an entity, such as a human, moves in front of a backdrop, such as a wall, the temperature at that point in the sensor's field of view rises from room temperature to body temperature, then falls back to room temperature, creating a temperature change. When a PIR sensor is set up in differential mode, it can be used as a motion detection device. When a human movement is detected inside the PIR sensor's "line of sight," this mode is enabled.

3.3 PROXIMITY SENSOR

A proximity sensor detects the presence of objects in close proximity without requiring physical contact. A proximity sensor sometimes emits an electromagnetic field or a pulse of electromagnetic radiation (infrared, for example) and monitors the field or return signal for adjustments. The target of the proximity sensor is the object that is being sensed. Different sensors are needed for various proximity sensor targets. A capacitive proximity sensor or a photoelectric proximity sensor, for example, can be used with a plastic target, while an inductive proximity sensor requires a metal target. Since there are no mechanical parts in proximity sensors, they can have high reliability and a long functional life.

3.4 Vivado Design SuiteHLx Editions - Accelerating High Level Design

The new Vivado Design Suite HLx editions supply design teams with the tools and methodology needed to leverage C-based design and optimized reuse, IP sub-system reuse, integration automation and accelerated design closure. When coupled with the UltraFast High-Level Productivity Design Methodology Guide, this unique combination is proven to accelerate productivity by enabling designers to work at a high level of abstraction while facilitating design reuse.

Accelerating High Level Design

- Software-defined IP Generation with Vivado High-Level Synthesis
- Block-based IP Integration with Vivado IP Integrator
- On demand reconfiguration with Dynamic Function eXchange (DFX)
- Model-based Design Integration with Model Composer and System Generator for DSP

Accelerating Verification

- Vivado Logic Simulation
- Integrated Mixed Language Simulator
- Integrated & Standalone Programming and Debug Environments
- Accelerate Verification by >100X with C, C++ or SystemC with Vivado HLS
- Verification IP

Accelerating Implementation

- 4X Faster Implementation
- 20% Better Design Density
- Up to 3-Speedgrade Performance Advantage for the low-end & mid-range and 35% Power Advantage in the high-end

CHAPTER - 4

MODELLING OF HOME ALARM SYSTEM

An alarm system is made up of a control panel, arming stations/keypads, sensors, sirens, and special lighting or vibration pads if necessary.

4.1 CONTROL PANEL

The control panel is the “brain” of the alarm system. It is usually installed in a closet or other out of the way place. When any sensor that is part of the system activates, it transmits a signal to the control panel. The control panel then activates the audible sounding device, and the communicator if the system has one. The control panel turns the system on and off via remote arming stations. It also includes the alarm system’s power supply and standby/backup battery.

4.2 ARMING STATION

The arming station, also called a keypad, can be either a key operated arming station, requiring the use of a high security key, or, most commonly used, a digital keypad, similar to a touch tone phone. A pre-set combination number is entered in the key pad that arms and disarms the system. Some keypads allow the user to assign a temporary code to a babysitter or houseguest, and then delete the code when it is no longer needed. The keypad is used to turn the system on and off. The user selects a function and enters a personal code to validate the entry. Most keypads also have a “panic” button or number sequence that will immediately activate the alarm and alert the monitoring service. This button or number sequence will function whether the system is on or off.

Some keypads allow the use of a hostage, or duress, code, which is different from the normal everyday code used. This feature can be utilized if the user is being held against his will, or if an intruder orders him to deactivate the system so an alarm signal cannot be sent. By using the hostage code instead of the normal code, it appears as if the system has been deactivated; however, the system will actually send a silent signal to the monitoring company, who in turn will call the police immediately. The monitoring company will not call inside the premises to verify the alarm if a hostage code is received. The siren is an electronic component that emits a loud, hard to ignore sound when activated by the control panel if an intrusion is detected, or when an audible panic button is pressed.

4.3 SIREN

Sirens can be mounted in plain sight, or they can be concealed in an overhang, soffit, attic or other out of the way place. Strobe lights flash and can use various colored lenses to indicate different events, for example, fire vs. burglary. The flashing can attract more attention than just a siren, and can help make it easier for emergency personnel to locate an alarm. Strobe lights are also used in combination with a vibrator pad or pager for the hearing impaired, so they are able to “see” or “feel” when their alarm is set off and take the appropriate actions.

4.4 DOOR SENSORS

Door sensors are magnetic switches that activate an alarm signal when a door is opened, after the system is placed into “armed” mode. They are also commonly called contacts, and can be used on windows as well. The switch is mounted to the door and the magnet is mounted to the frame directly in line with the switch. This holds the switch in a closed position. When the door is opened, the switch moves away from the magnet, causing the switch to open, which in turn causes the alarm panel to activate an alarm signal indicating an intrusion. Door sensors should be mounted on all ground floor entry/exit doors and any upper story entry/exit doors that are accessible by a staircase or permanent ladder. Because these sensors are subject to repeated opening and closing, as well as various weather conditions, they should be checked on a semi-annual basis to be sure the alignment is still correct and the switch is still functioning properly. This is especially true if the sensors are placed on a newly installed door, or during any new construction, as normal settling may have an effect on the alignment. Replace worn switches, and realign them as necessary to maintain the integrity of the system.

4.5 MOTION DETECTORS

Motion detectors are used to signal the entry of an intruder into a specific area. They are typically mounted on a stable interior wall or ceiling, and can be set to cover areas of various sizes. Some have a “pet alley” built in, which is designed to eliminate false alarms caused by pets moving in the alarmed areas. There are several different types of motion detectors, and which one to use will be determined by the area that needs to be protected. For most residential applications, a Passive Infrared (also called a PIR) sensor is used. The sensor head is typically divided into sectors or zones, with each covering specific areas with specific boundaries. PIR sensors detect the change of thermal radiation that occurs when an intruder enters a covered zone. They see "hot" images by sensing the contrast between the "hot" image and the cooler background. When the radiation change captured by the PIR exceeds a pre-set value, the thermal sensor produces a signal that is sent to the built-in processor for evaluation, and if appropriate, the alarm signal is activated. Microwave sensors are designed to flood a designated area with an electronic field and are programmed to recognize the Doppler shift frequencies that are most closely associated with human movement. When movement occurs in the area and disturbs the electronic field, the processor determines whether the signal being received falls within a pre-set limit, and if appropriate, the alarm signal is activated.

Ultrasonic Detectors are motion detectors that emit ultrasonic sound energy into an area using air as its medium, which travels in a wave type motion. The sensor "hears" a certain pitch characteristic of the particular environment. If an intruder enters the room, the wave pattern is disturbed and reflected back more rapidly, thereby increasing the pitch and activating the alarm. Dual-tech PIR/Microwave and PIR/Ultrasonic detectors use a combination of both passive (PIR) and active (Microwave or Ultrasonic) sensors, and provide the lowest false alarm potential as signals for both heat and motion must be received by the processor before the alarm is activated. Audio detectors consist of two modules; a microphone that "listens" for noise, and an amplifier that includes processing circuitry to analyze the sounds. The amplifier is calibrated to a noise threshold that is characteristic of an intrusion attempt, and activates the alarm if a certain amount of noise is detected from a monitored area within a pre-set time period. Photoelectric detectors, also called "beams", are most often used in commercial applications such as garages, warehouses, schools and office buildings. Beam systems consist of a transmitter that uses LED as a light source, and a receiver that contains a photo-electric cell. An infrared beam is sent from the transmitter to the receiver, essentially creating a “trip wire”. If the beam is broken or interrupted, or if the receiver fails to receive at least 90% of the transmitted signal for a pre-set period of time, the alarm is activated. Beam systems require routine maintenance, especially when used in an outdoor application, and the alignment should be checked and calibrated monthly.

CHAPTER - 5

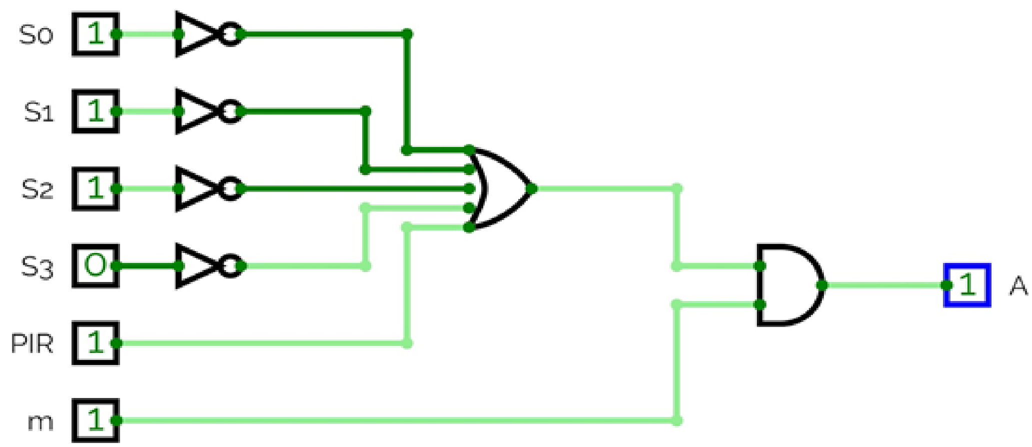
LOGIC DESIGN

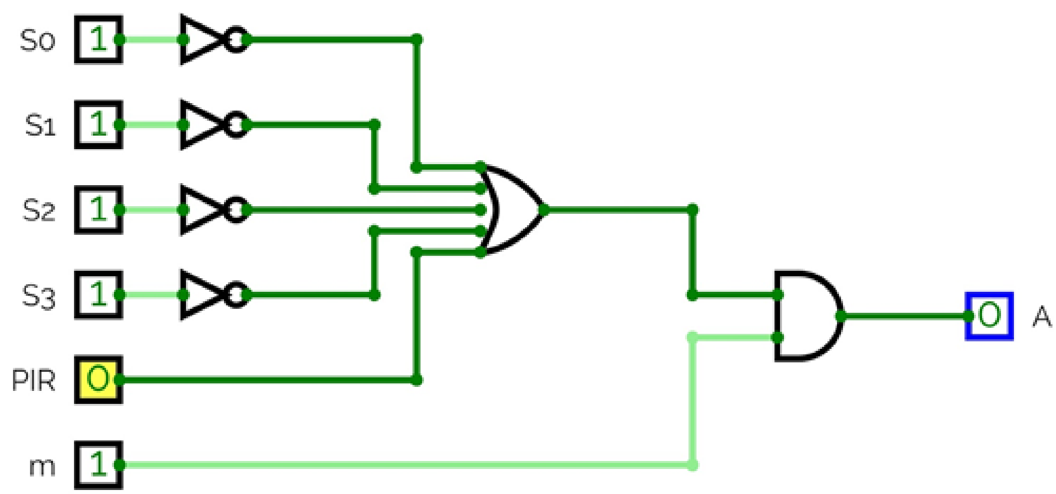
The proximity sensor, on detection of any activity, will change its state to 0. Every door and window is fitted with a proximity sensor each. The movement sensor changes its state to 1 upon detecting a moving object. The output of these sensors is fed as inputs to the OR gate. The main switch installed in order to enable the entire alarm system, is one of the inputs to the AND gate along with the output of the OR gate.

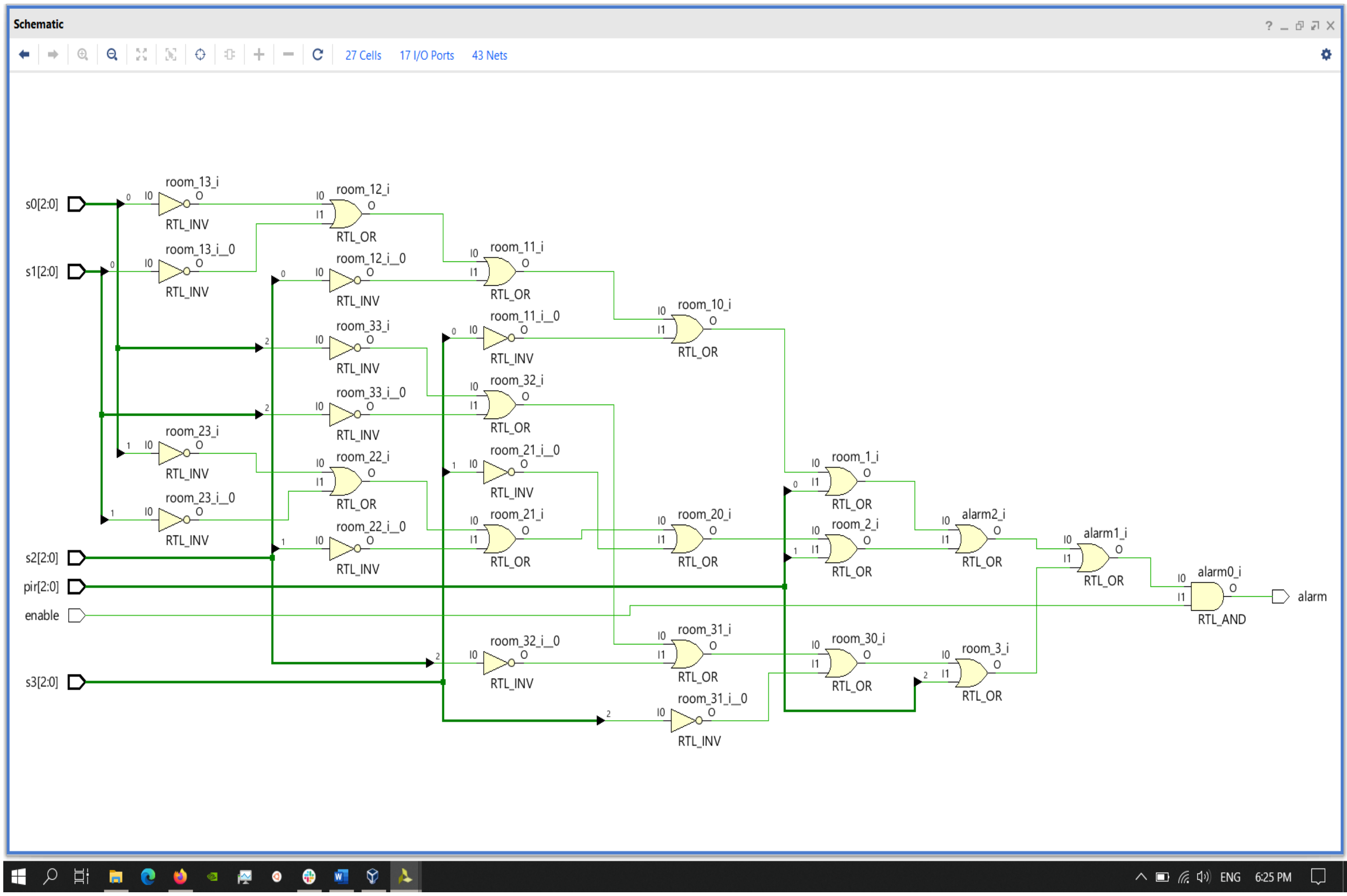
In figure 5.1, we can see that there is a movement that has been detected by the movement sensor as well as the proximity sensor. As the main switch has been enabled we can see that the alarm has been activated.

In figure 5.2, we can see that there is no movement that has been detected by the movement sensor as well as the proximity sensor. Though the main switch has been enabled we can see that the alarm has not been activated due to absence of movement.

In case, there is movement that has been detected by the movement sensor or the proximity sensor but where the main switch has not been enabled, then the alarm does not go off. This mode can be used whenever the resident is at home.


So
S1
S2
S3
PIR
m
1
1
1
O
1
1
1
A


So
S1
S2
S3
PIR
m
1
1
1
1
O
1
O
A

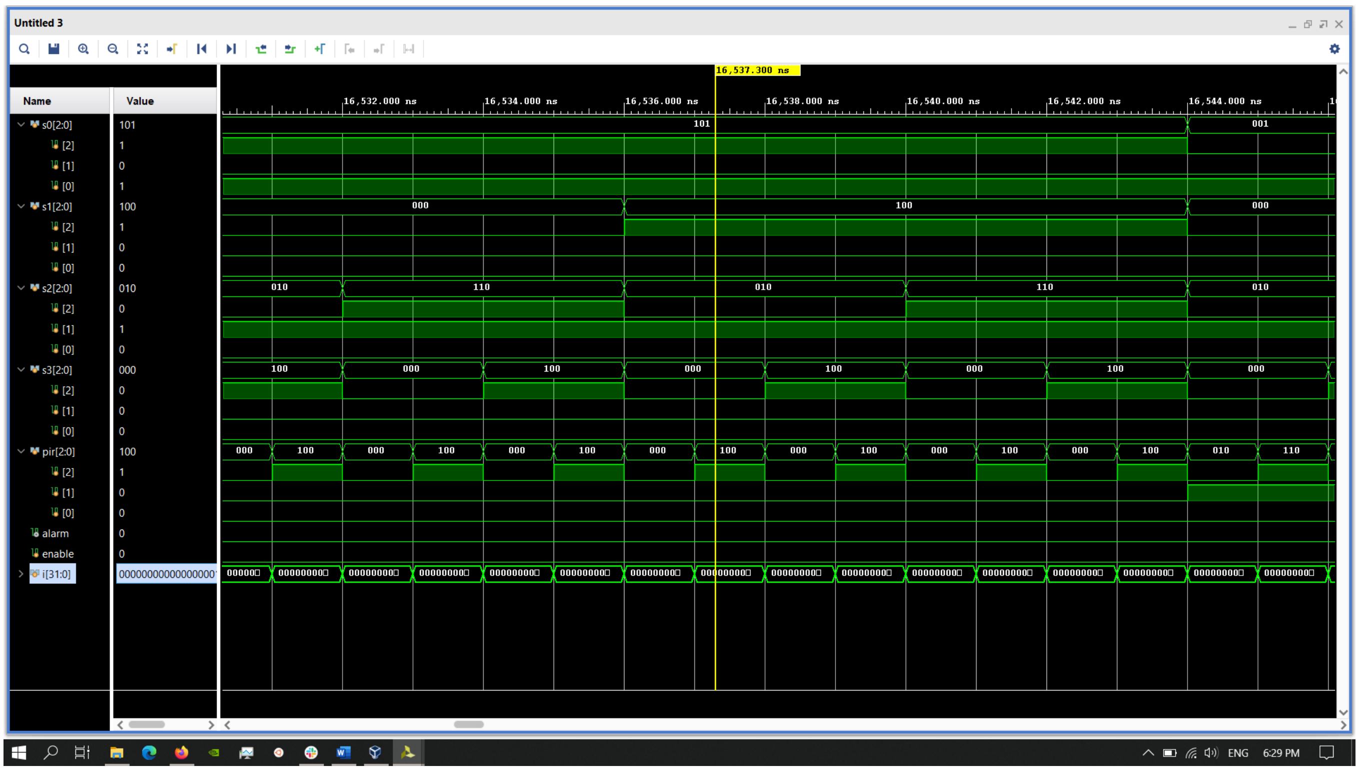


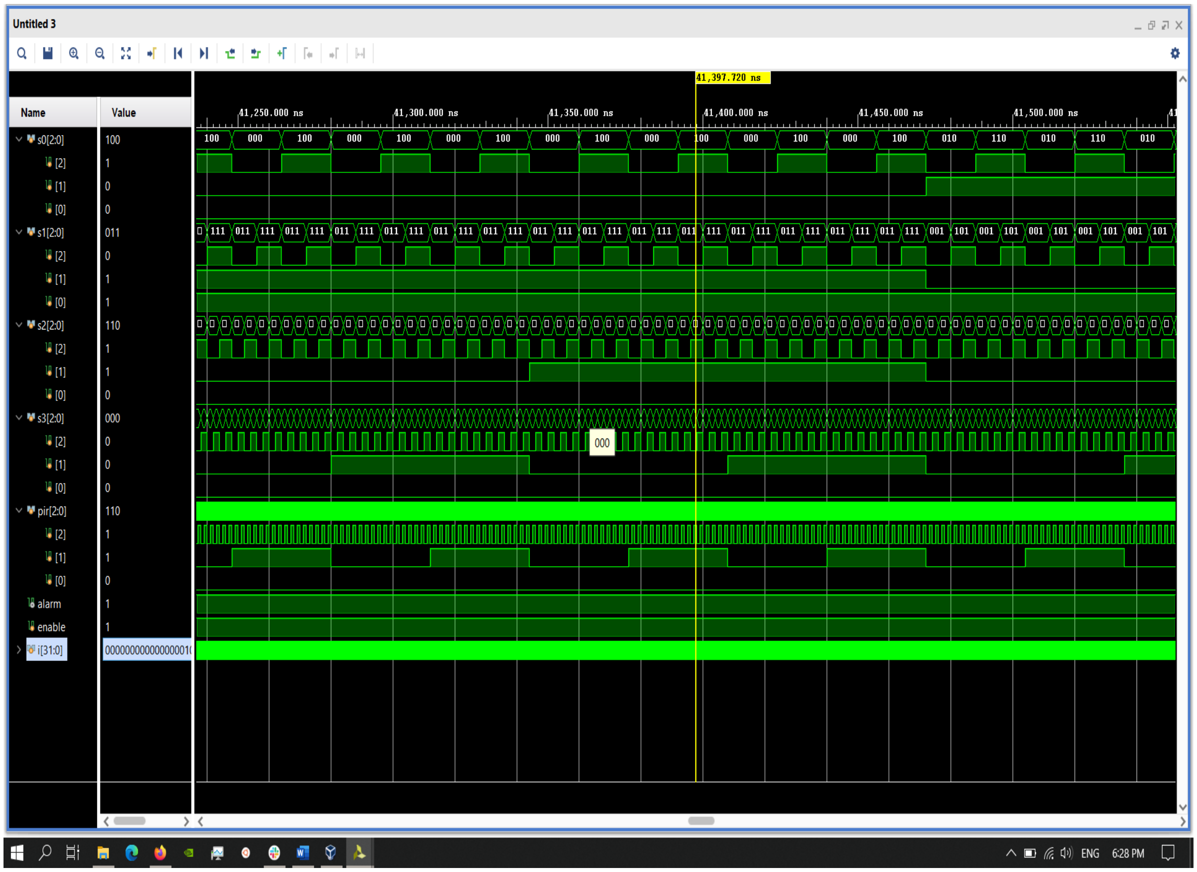
Schematic
27 Cells
17 I/O Ports
43 Nets
s0[2:0]
s1[2:0]
s2[2:0]
pir[2:0]
enable
s3[2:0]
room_13_i
room_13_i__0
room_23_i
room_23_i__0
room_12_i
room_12_i__0
room_33_i
room_33_i__0
room_22_i
room_22_i__0
room_11_i
room_11_i__0
room_32_i
room_21_i__0
room_21_i
room_32_i__0
room_10_i
room_20_i
room_31_i
room_31_i__0
room_1_i
room_2_i
room_30_i
room_3_i
alarm2_i
alarm1_i
alarm0_i
RTL_INV
RTL_OR
RTL_AND
alarm
ENG
6:25 PM

CHAPTER - 6

RESULT AND OBSERVATION

6.1 RESULT





6.2 OBSERVATION

In the output waveform, the alarm signal becomes high when the output of proximity sensor changes to logic level 0 or that of movement sensor changes to logic level 1. Similarly**,** for normal state of the sensors the alarm signal remains low, thereby indicating that the home is secure.

CHAPTER – 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

This chapter concludes the design and simulation of home alarm systems. The objective of this project is to alert users if and when there is any trespassing or abnormal activity. In the proposed work, Vivado Design Suite is used to simulate the FPGA implementation of the home alarm system. Proximity sensors and movement sensors are used to detect intrusion and alert the user about the same with the help of an alarm.

7.2 FUTURE WORK

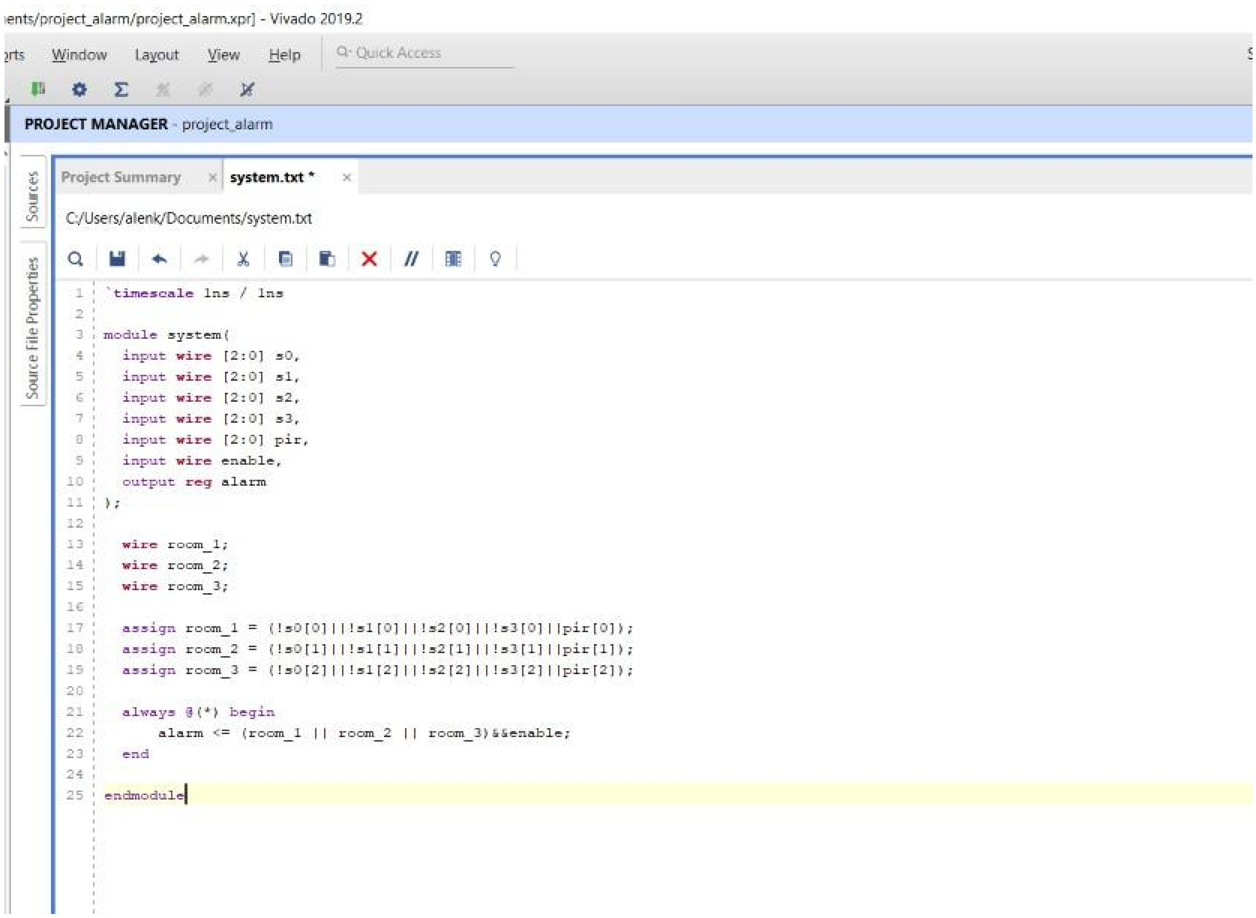
For the hardware implementation of the system the Basys 3 FPGA board can be used. Besides the used sensors we can also add another feature to identify the authorised person thereby providing a secure and foolproof environment.

To enhance the security of the system, we can also incorporate passwords and LED display. Only on entering the correct password, the system would get activated or deactivated. The LED display can be used to show the status of the system as active or inactive. If the alarm goes off, the authorised person will have to type the correct password to turn it off.

APPENDIX

This appendix contains the code to design the home alarm system.

DESIGN CODE




```
`timescale 1ns / 1ns

module system(
  input wire [2:0] s0,
  input wire [2:0] s1,
  input wire [2:0] s2,
  input wire [2:0] s3,
  input wire [2:0] pir,
  input wire enable,
  output reg alarm
);

  wire room_1;
  wire room_2;
  wire room_3;

  assign room_1 = (!s0[0]||!s1[0]||!s2[0]||!s3[0]||pir[0]);
  assign room_2 = (!s0[1]||!s1[1]||!s2[1]||!s3[1]||pir[1]);
  assign room_3 = (!s0[2]||!s1[2]||!s2[2]||!s3[2]||pir[2]);

  always @(*) begin
      alarm <= (room_1 || room_2 || room_3)&&enable;
  end

endmodule
```

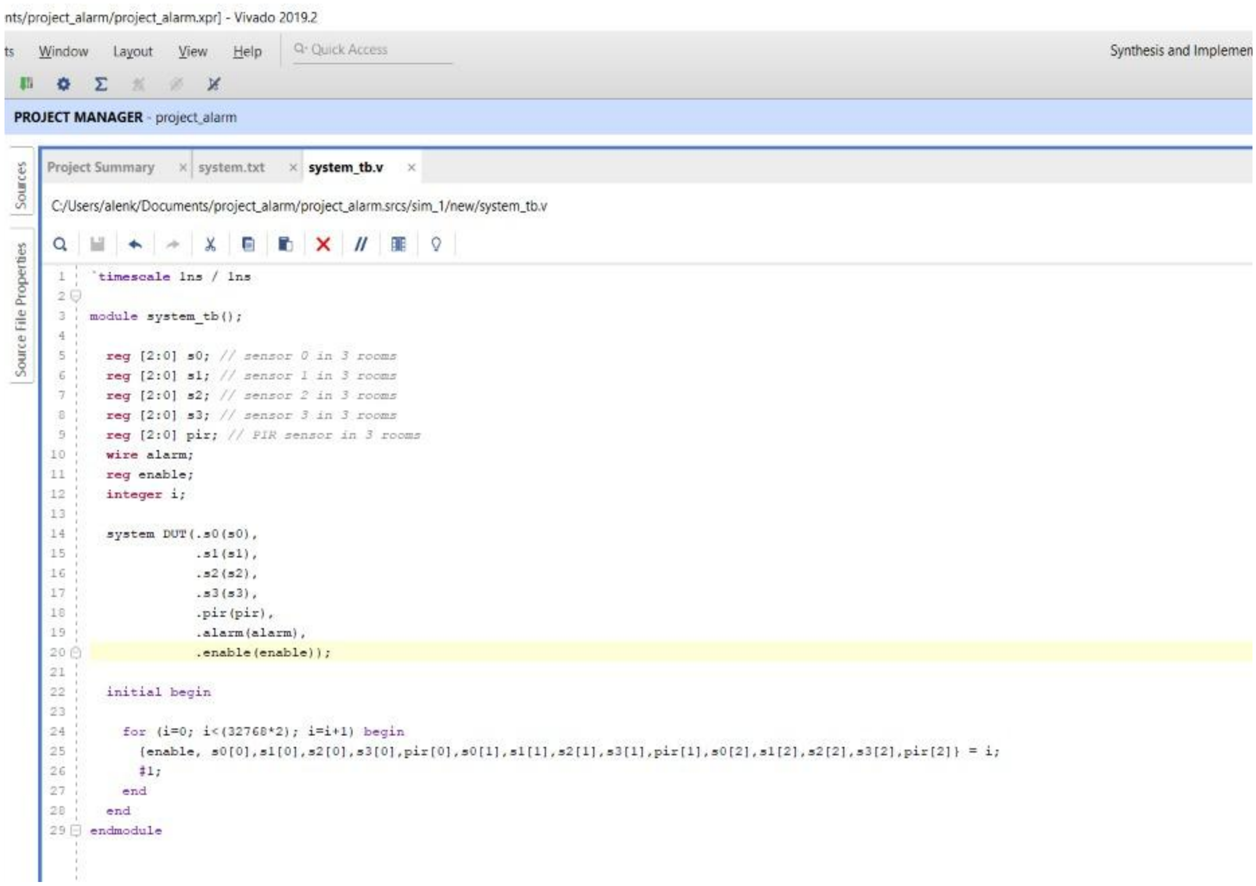
```
module prob1(input wire
s0_0,s1_0,s2_0,s3_0,pir_0,enable,s0_1,s1_1,s2_1,s3_1,pir_1,s0_2,s1_2,
s2_2,s3_2,pir_2, output wire alarm);

  assign alarm =
((!s0_0||!s1_0||!s2_0||!s3_0||pir_0)||(!s0_1||!s1_1||!s2_1||!s3_1||pir_1)||(!s0
```

_2||!s1_2||!s2_2||!s3_2||pir_2))&& enable;

endmodule

TEST BENCH



module prob1_tb();

reg s0_0,s1_0,s2_0,s3_0,pir_0,enable,s0_1,s1_1,s2_1,s3_1,pir_1s0_2,s1_2,s2_2,s3_2,pir_2;

```
    wire alarm;


  prob1
prob1_test(s0_0,s1_0,s2_0,s3_0,pir_0,enable,s0_1,s1_1,s2_1,s3_1,pir_1,
s0_2,s1_2,s2_2,s3_2,pir_2, alarm);


    initial begin
        //$monitor(a,b,c,d,out);
      $dumpfile("dump.vcd");
      $dumpvars(0,prob1_test);
      for (int i=0; i<4194304; i=i+1)
        begin
{s0_0,s1_0,s2_0,s3_0,pir_0,enable,s0_1,s1_1,s2_1,s3_1,pir_1,s0_2,s1_2
,s2_2,s3_2,pir_2} = i;
        #10;
        end
    end
endmodule
```

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