



## **FPGA BASED HOME SECURITY SYSTEM**

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### **ABSTRACT**

The project aim is to design and implementation of a home security system with the use of FPGA. Home security system becomes the best solution to overcome house intrusion problem and to avoid any kind of accidents occur in house when user is in house or not. There are many home security systems, but they are too expensive and difficult to use for normal people. So many people can't afford and understand them. For that reason, an effective home security system at low cost and easy to use is built. Where normal people can afford and use it without any problems.

This project mainly focusing on developing home security system with an infrared motion detector, fire, smoke, gas sensor is controlled by FPGA (Field Programmable Gate Array) which is programmed by Verilog language. As a result, the infrared detector, gas sensor, fire sensor and smoke sensor are capable to control the whole operation of security system. In case of fire accidents or any intruders, chip will receive signals from the different sensors in the monitoring place and acts according to the received signals by sending message with picture of accident to user's mobile phone, it works as automatic and immediate reporting to the user in case of emergency which will help us to reduce the damage caused by accident and intruders. ESP32 Cam Wi-Fi module is used to capture the image and send to the user mobile. FPGA programming is capable to control the whole operation of the security system.

**Keywords :** *FPGA, VLSI, HDL, Verilog*

### **I. INTRODUCTION**

Home Security systems are commonly found in electronics form with the help of recent technology. Automation is the use of scientific and technological principles in the manufacture of machines that take over work normally done by humans. The manual security provided to the property of individuals or industries is costlier and laborers. Human errors may affect the whole security drastically and single mistake may fail the whole purpose. Hence automation in the security purpose is necessary. There are some high-quality security systems already available in the market. It is easier to just pay to have professional company to install security system. Many individuals who rent their homes, such as apartment owners, are usually not allowed to install permanent devices in their homes. Also, most inexpensive home security devices and components are nothing more than cheap and ineffective noise makers.

This report presents implementation of security system based on VLSI technology. The different types of sensors are mounted at the places from where the person may enter in the house.



On compound wall or window entrance IR sensor can be fixed, gas sensor used to monitor the gas leak in the air, smoke sensor used to monitor the Smoke in the air. There are now two industry standard hardware description languages, VHDL (Very High-Speed Integrated Circuit Hardware Description Language) and Verilog. The complexity of FPGA designs has meant an increase in the number of specialist design consultants with specific tools and with their own libraries of macro and mega cells written in either VHDL or Verilog. So, the objective of minimizing human efforts is going towards completion.

### **Problem statement.**

There are several users' needs in security variations that the system should address. Not all users will demand the same type of security, nor do all users want this security at the same time. The system should be able to provide appropriate levels of security while occupants are away from their residence.

Finally, much attention has been given to securing the house itself, but for users who desire the safeguarding of items that are not only in their house but on the premises, features must allow for arming of circuits outside of the house. Some applications of this could be the arming of entrances to carports and garages, supply closets, tool sheds, and backyards. In addition, users may wish for this feature to exclude uninvited parties from their property so as to avoid liability claims, such as negligence to safeguard a swimming pool or dangerous equipment.

## **II. LITERATURE SURVEY**

Security is a major concern in our daily life. Everybody desires to be as much safe as possible. The progressive home security system has improved to the present security system in our day-to-day life. Security systems for homes protect from the thief. The security in the home has to start the owner of the home and to look after the home. The finest way to guard the home is by connecting the security system in the home.

The most important things for a person are property and life, and he aims to secure these. Home Security System fulfils this need. In olden days people used to secure the homes when they leave by using locks and key. Research has been conducted regarding automated home monitoring.

One of the research projects done was on an advanced Internet of Thing based Security Alert System for Smart Home to detect an intruder or any unusual event at home, when nobody is available there. Here, we utilize the camera for catching the present action of your home. Camera is catching the picture and offer back to the raspberry pi with the goal that it sends the email to the owner whose mail id was already put away inside it.

The email is sent through IMAP (Internet message get to convention). For that the raspberry pi is associated with the Internet through either RJ45 or the WIFI module. This Home security provision using raspberry pi and Web Camera is in economical and not feasible, also requires high maintenance. Also, there is a need of internet connectivity for this system. In microcontroller based home security system with GSM Technology. In input section, a mobile phone through a Bluetooth device has been used for interfacing with microcontroller to lock or unlock the door of the system.

Consequently, a manual keypad per-forms the similar function without communication with



Bluetooth device. On the other hand, pressure sensors have been placed both at door and window to protect the system. According to the pulse of input devices, the controller section takes decision and activates the output section which includes LCD display, GSM Module, Servo Motor, LED, and Buzzer. The disadvantage of this type of system is large hardware.

There are some systems which only detect the motion of object example PIR motion detectors. PIR motion detectors are perhaps the most frequently used for security device. Passive IR motion detectors are usually designed to provide an indication to an alarm panel in response to detecting IR that is indicative of motion of the object. The alarm panel is responsive to receipt of the breach indication to cause an alarm condition to occur.

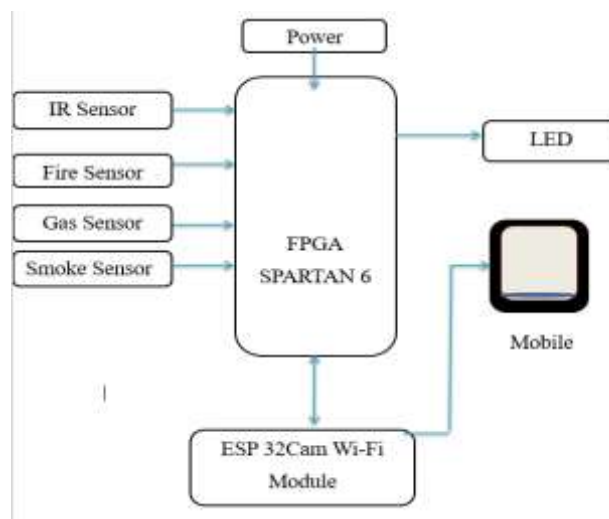
In case of fire/security the chip will receive signals from the different sensors in the monitoring place and acts according to the received signal by sending an SMS message to user's mobile phone it work as automatic and immediate reporting to the user in case of emergency for home security, as well as immediate and automatic reporting to the fire brigade and police station according to activated sensor to decrease the time required for tacking action. But these types of systems are not suitable for wide range.

As per our survey currently there are various systems which are hard to install, difficult to use and maintain. Systems are generally proprietary and closed, not very customizable by the end user.

- N. Sriskanthan explained the model for home automation using blue tooth via PC. But unfortunately, the system lacks to support mobile technology.
- D. Javale explained the model for home automation and Security System Using Android ADK to control various home appliances with Android smart phone but wait for and detect connected devices.
- Al-Ali and Al-Rousan presented a design and implementation of a Java-based automation system through World Wide Web. It had a standalone embedded system board integrated into a PC-based server at home.
- R. Piyare have introduced design and implementation of a low cost, flexible and wireless solution to the home automation.

### **III. PROPOSED FPGA BASED HOME SECURITY SYSTEM**

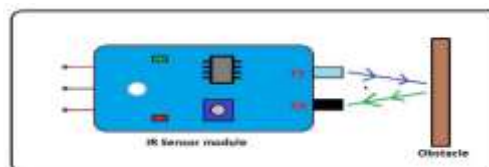
#### **Block Diagram**



**Fig 1. Block Diagram of FPGA Based Home Security System**

### IR Sensor

The IR Sensor Module or infrared (IR) sensor is a basic and most popular sensor in electronics. It is used in wireless technology like remote controlling functions and detection of surrounding objects/ obstacles. IR sensors mainly consist of an Infrared (IR) LED and a Photodiode, this pair is generally called IR pair.



**Fig 2. Working of IR Sensor Module**



**Fig 3. Infrared Sensor Module**

### Gas Sensor

The MQ-6 module is used in gas leakage detecting equipment in family and industry, this module has high sensitivity to LPG, iso-butane, propane, and LNG. The module also has an onboard comparator for comparing against an adjustable preset value and giving out a digital high or low. It can be easily interfaced with your Arduino, Raspberry Pi and FPGA. LPG (composed of mostly propane and butane) concentrations in the air.



**Fig 4. MQ-6 Gas Sensor**

This sensor contains a sensing element, mainly aluminum-oxide based ceramic, coated with Tin dioxide, enclosed in a stainless steel mesh. Sensing element has six connecting legs attached to

it. Two leads are responsible for heating the sensing element, the other four are used for output signals.

### Smoke Sensor

A smoke sensor is a device that senses smoke, typically as an indicator of fire. Detectors may use one or both sensing methods. Sensitive alarms can be used to detect and deter smoking in banned areas. Smoke detectors in large commercial and industrial buildings are usually connected to a central fire alarm system.



Fig 5. MQ-2 Smoke Sensor

### ESP32 Cam Wi-Fi Module

The ESP32 CAM Wi-Fi Module Bluetooth with OV2640 Camera Module 2MP For Face Recognition has a very competitive small-size camera module that can operate independently as a minimum system with a footprint of only 40 x 27 mm; a deep sleep current of up to 6mA and is widely used in various IOT applications. It is suitable for home smart devices, industrial wireless control, wireless monitoring, and other IOT applications.



Fig 6. ESP32 Cam Wi-Fi Module

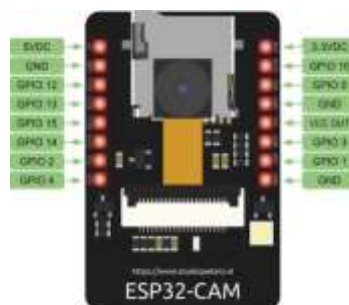


Fig 7. ESP32 Cam Wi-Fi Pin Diagram

### 3.1.5 FIRE SENSOR

This Flame Sensor Module is used to detect fire/flame source or other light sources of the wavelength in the range of 760nm – 1100 nm. The module has 2 outputs: Analogue, which gives a real-time voltage output signal on thermal resistance, and digital which allows temperature

thresholds to be set via a potentiometer.



**Fig 8. Fire Sensor.**

### 3.1.6 Spartan 6

The Spartan6 FPGA Project Board is a digital system development board which features Xilinx Spartan6 FPGA, 16Mb of external non-volatile memory and enough I/O devices and external connector to interface variety of digital applications.



**Fig 9. Spartan 6**



**Fig 10. Architecture of Spartan 6**

Attributes	Values
Weight	0.11 lbs.
Dimensions	5x3x1 in
Product Dimensions	2.60x2.45x0.51 in
FPGA	XC6SLX9
Number Of Clock Sources	1
Primary Clock Frequency	100 MHZ
Number Of GPIOs (Max)	70

**Table 1. Specifications of Spartan 6**

### Working

The security system assembled using VLSI technology. This system is affordable to appeal to





the public. Reliable to operate without failure. Effective to provide a sense of security. Advantages of VLSI based projects are smaller size, lower cost, lower power, more functionality. The home security make owner secure and comfortable as possible. With the help of modern technology, the control over home appliances will be possible.

The main controller is FPGA which will programmed by Verilog language by using XILINX software. For detection various sensors like Fire sensor, smoke sensor, IR sensor, and gas sensor are used. So, we use smoke sensor to detect the occurrence of fire accident as soon as possible by the presence of some special particles in smoke.

The block diagram mainly consists of four sensors, FPGA, power supply and ESP32 Cam Wi-Fi module. We are using sensors like IR, fire, gas, smoke. IR sensor is used to detect the motion. These can be placed near doors, windows, and gates. Through Wi-Fi module the message with intruder picture is send to the user mobile. Here a ESP cam Wi-Fi is used to capture the picture. Fire sensor senses the fire if any and send message to user mobile with a picture.

Smoke sensor is used to detect the smoke in surrounding areas. Whenever a fire accident occurs, smoke sensor detects the smoke and sends signal to chip. Gas sensors are mostly placed in kitchens when there is any gas leakage from LPG gas sensor detects the gas and warns the user.

We are using Spartan 6 FPGA model. FPGA is connected to the ESP 32 cam Wi-Fi module. These are used to communicate with mobile. A message is sent to the user mobile with the help of Wi-Fi module. A LED will blink if any one of the sensors is activated.

### **Xilinx**

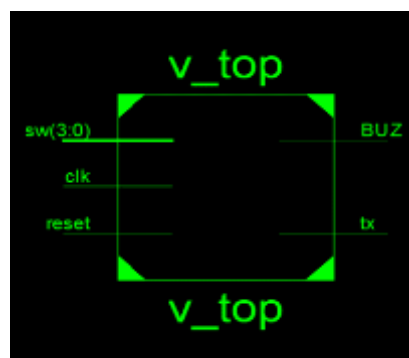
In this project we are using Xilinx 14.7 software. The Xilinx Software Development Kit (XSDK) is the Integrated Design Environment for creating embedded applications on any of Xilinx's award-winning microprocessors. These libraries and drivers can scale for the custom-design based on feature needs, memory requirements and hardware capabilities.

### **Verilog**

Verilog is a Hardware Description Language (HDL). A subset of statements in the Verilog language are synthesizable. Verilog modules that conform to a synthesizable coding style, known as RTL, can be physically realized by synthesis software.

## **IV. RESULTS ANALYSIS**

### **RTL Schematic**



**Fig 5.1:- RTL Schematic of FPGA based home security system**

Here SW (3:0) indicates four sensors i.e. IR, gas, smoke, fire. 100MHz clock is given as the one of the inputs. Reset pin is used to reset the FPGA. The whole module is named as v\_top.



(3:0), clk, reset is the input to the module v\_top. The outputs of the module are Buzz and tx. The buz is nothing but a LED which goes high if any one of the sensors sense the value.

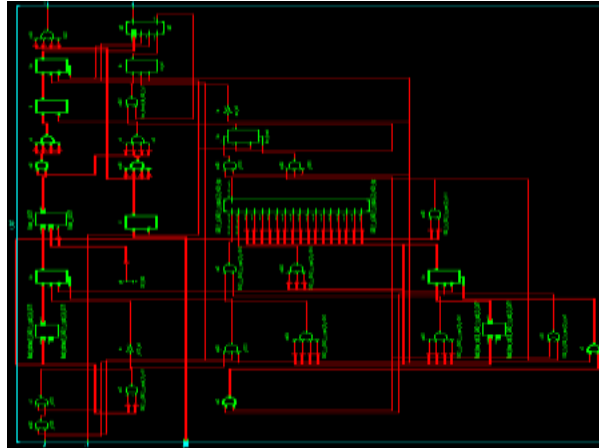
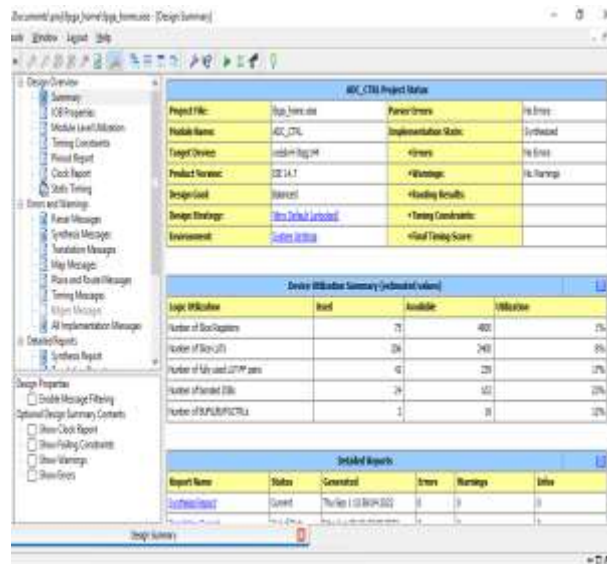


Fig 11. Expanded RTL Schematic of FPGA based home security system.

**SYNTHESIS REPORT**  
**SOURCE PARAMETERS**  
 Input File Name : "v\_top.pj3"  
 Ignore Synthesis Constraint File : NO  
**TARGET PARAMETERS**  
 Output File Name : "v\_top"  
 Output Format : NGC  
 Target Device : xc6slx0-3-tqg144  
**SOURCE OPTIONS**  
 Top Module Name : v\_top  
 Automatic FSM Extraction : YES  
 FSM Encoding Algorithm : Auto  
 Safe Implementation : No  
 FSM Style : LUT  
 RAM Extraction : Yes  
 RAM Style : Auto  
 ROM Extraction : Yes  
 Shift Register Extraction : YES  
 ROM Style : Auto  
 Resource Sharing : YES  
 Asynchronous To Synchronous : NO  
 Shift Register Minimum Size : 2  
 Use DSP Block : Auto  
 Automatic Register Balancing : No  
**Target Options**  
 LUT Combining : Auto  
 Reduce Control Sets : Auto  
 Add IO Buffers : YES  
 Global Maximum Fanout : 100000  
 Add Generic Clock Buffer (BUFG) : 16  
 Register Duplication : YES  
 Optimize Instantiated Primitives : NO

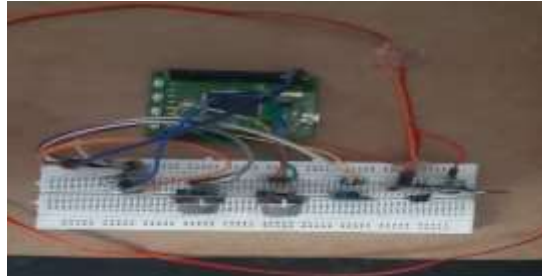
**HDL Synthesis Report**  
**Macro Statistics**

# RAMs	: 2
16x8-bit dual-port RAM	: 1
4x32-bit single-port Read Only RAM	: 1
# Adders/Subtractors	: 7
10-bit adder	: 1
2-bit adder	: 1
27-bit adder	: 1
3-bit adder	: 1
4-bit adder	: 3
# Registers	: 15
1-bit register	: 5
2-bit register	: 1
27-bit register	: 1
3-bit register	: 1
4-bit register	: 4
8-bit register	: 2
9-bit register	: 1
# Latches	: 8
1-bit latch	: 8
# Comparators	: 2
4-bit comparator not equal	: 2
# Multiplexers	: 11
1-bit 2-to-1 multiplexer	: 2
3-bit 2-to-1 multiplexer	: 1
32-bit 2-to-1 multiplexer	: 1
4-bit 2-to-1 multiplexer	: 5
4-bit 4-to-1 multiplexer	: 1
8-bit 2-to-1 multiplexer	: 1
# FSMs	: 1



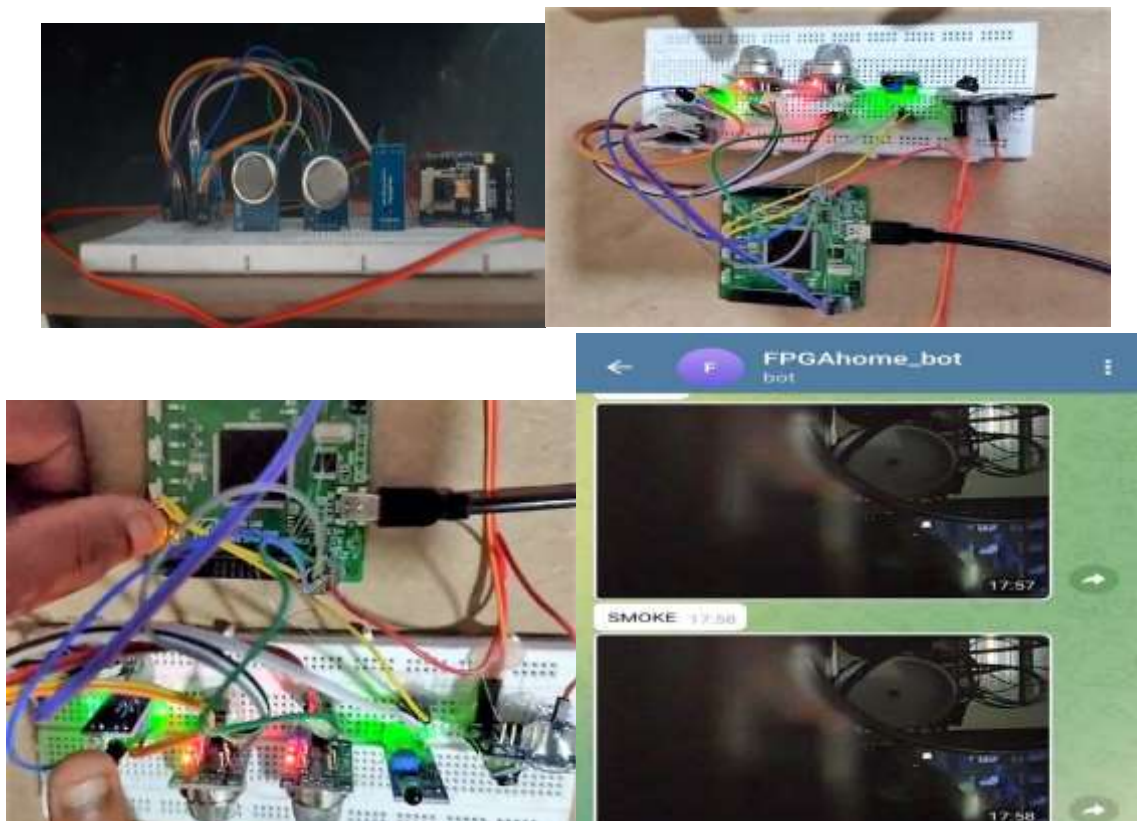


**Fig 12. Summary Report of FPGA based home security system.**



**Fig 13. Hardware of FPGA based home security system.**

Here in the figure 13. we can see there are four sensors IR, gas, smoke, Fire. These four sensors are connected to a Spartan 6 FPGA board. All sensor inputs are connected to the P1 port of FPGA. ESP32 Cam Wi-Fi is used to capture the picture of accident or intruders. The ESP32 is given to the FPGA P1 through jumper wires. VCC and ground connections are made using jumper wires. The FPGA program is written using Verilog language in Xilinx software. The program is dumped into FPGA by using mimas configuration tool. The configuration tool and FPGA are of version 1. The working of the kit is as follow, if any incident like fire accident, gas leakage, and intruders occurs the sensor senses and send digital output to the FPGA. And the report of the captured picture is sent to the FPGA. Through telegram bot the user will receive a message about the incident with the picture. With this the user will have awareness about the accident occurred in the home. So, the user can protect the home. By this FPGA based home security system we can provide the security to our home.



**Fig 14. Output of FPGA based home security system.**



### CONCLUSION & FUTURESCOPE

The implementation of home security system using FPGA is achieved. In this paper we introduce different sensor and control system using FPGA. This system is suitable for monitoring home by sensing with the help of various sensors. Here we programmed using Verilog language. When any accident occurs, the FPGA receives signal from sensors. To alert the user a photo with a message is sent to the mobile. The output has been verified.

This VLSI system is further modified for the many applications. It can be used in office. It is also used in industry in many applications. By adding video camera (for cost effective purpose), this system can be used as low-cost home security system for apartments. We can provide 6V, 4 or 5 Ah battery back up to our system so that in case of power failure our project works properly. Instead of hiring security guards (which is quite expensive), now smart homes in modern societies are equipped with such home security systems. Modern Home Security systems are even linked with local police or security agencies for emergency help. Moreover, these security systems are not bound to homes only, nowadays offices, banks, shopping malls etc. are all equipped with such smart security systems.

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