FPGA Based Home Automation System

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Abstract- *The houses of 21st century are about to become more human controlled and automated that is without his presence he would control all the household appliances. The need for Smart Automation through mobiles is increasing. This paper describes the use of the FPGA (Field Programmable Gate Array) controller for the home automation purpose. The Wi-Fi (Wireless Fidelity) is the wireless medium used in order to ease the automation purpose through an android mobile phone and a FPGA controller. The high operating frequency of FPGA and low cost brings up the novelty in this the proposed work.*

Keywords- FPGA Controller, Smart Home, SMS, Bluetooth, RF Module, Mobiles, Sensors, Matlab, Wireless Fidelity (Wi-Fi), Android Mobile Application.

I. INTRODUCTION

The advancements taking place in the technology field have played an important role in making them an integral part of our life. Technology helps us in reducing our efforts that are needed even for performing small day to day work. Using technology we can control everything at home automatically without any human intervention. This is the reason why the home automation concept is in boom. The National Association of Home Builders (NAHB) brought up a new concept in the market in 1984 and that concept was termed as "Smart home". So, over this later period of time researching and advancements in this field continued to take place. But automating an entire structure that is a complete building is still a bit expensive piece of work [1]. So, the question: "Why opt for home automation, if expensive?"

To start with the benefits, first comes the word which is interoperability: adjusting of temperature values according to present conditions, turning on and off of lights or varying their intensity of brightness as per requirements. Second is, home automation will provide us remote accessing of the devices that one desires to control, one can monitor his home with the help of a laptop or PC or even his own phone. Third benefit is that we can alter or expand the smart automation of our house as per our need in cost effective manner. Hence it will aid in bringing expandability and saving of energy [2]. These days the concept of energy saving is of prime importance and awareness about it is growing among people. Automation serves the purpose of energy saving for example: the devices are turned on/ off automatically when they have served their purpose of use or whenever not in use.

A house that consists of such smart automation system offers more ease, comfort, flexibility, elegance, security and more importantly maintenance cost is reduced as consumption of electricity is optimized. For example: some smart homes implement simple things like turning on sprinklers by sensing the moisture of soil or alarming systems to notify the presence of thief. More advancement include adjustments of ambient light according to the presence of a person in the room, control the temperature etc.

The paper is structured as follows. In section 2, literature survey is presented on the existing FPGA based home automation systems. The proposed architecture of the system and the workflow of the system in m,mentioned in section 3. Section 4 describes the Graphical User Interface (GUI). Section 5 presents the results. The last section submits the conclusion remarks over the proposed system.

II. LITERATURE SURVEY

The objective behind literature survey is to study different technique used for Home Automation and the various platforms used for its implementation.

P. A. Bawiskar and Prof. R. K. Agrawal [3] featured a project that is a combination of VHDL features with sensor based circuitry for alarming and detection purpose as. This system used sensors like IR ,Wire, Magnetic, Temperature, Light and Smoke. It uses Matlab coding for displaying the status of sensors or to start/stop the messaging.Mobile is used to receive SMS notification. An FPGA is used which is connected to computer along with a GSM Modem. PC scans the sensor status and provides to mobile. They have sensed the various parameters but the feature of monitoring the status of door is not implemented which is also one of the prime security parameter.

N.Chintaiah, K. Rajasekhar, V. Dhanraj [4], have presented an Automation system based on GSM .Here there are 2 modes of execution, firstly Standalone mode and secondly GSM mode .System is implemented using Nexys2

circuit board based on Xilinx Spartan3 FPGA. This system can be used to check the device whether ON/OFF and user controls the device by sending SMS to system. The user and the controller will communicate with each other with the help of RS232 serial communication between them, this task is performed with the help of a GSM modem. The FPGA board used in this project is very costly around 349 dollars, so it is not that cost effective.

An Braeken, Jan Genoe, Serge Kubera, Nele Mentens, Abdellah Touhafi, Ingrid Verbauwhede, Yannick Verbelen, Jo Vliegen, Karel Wouters [5] they have worked on STRES (Secure Techniques for Remote Configuration of Embedded Systems) system. Here Xilinx ML507 board is brought in use. There are 2 divisions made in FPGA namely Dynamic zone and Static Zone. The STRES system is based on full STS protocol (Station To Station) that provides data confidentiality, entity authentication and key authentication. The cost of the communication unit used in this project is very high.

Mohamed S. Soliman, Majed O. Dwairi, Iman I.M. Abu Sulayman, Sami H.A. Almalki [6] with the help of Internet of Things have implemented the Home Automation architecture that works in Wired as well as Wireless configurations. Each case has 2 modes of operation: Manual and Automated. The two main hardware components that come in light are PC Home main Server and Arduino Uno Micro controller board. The MatLab GUI (Graphical User Interface) platform management and Arduino Uno Control Algorithm are included in the computer. Matlab is not a freeware so Android based GUI is more preferable and it is more user friendly. This project requires separate circuitry for the Wireless mode and in case of wired mode this makes the entire system very bulky.

Sweatha K N, Poornima M, Vinutha M. H. [7] they have presented a FPGA controller that controls the devices connected to it. The Bluetooth is used for wireless monitoring. Android phone is used for Speech recognition. The data that is received from the Bluetooth needs to get converted into a digital form; the micro controller does this job and passes this data further to the FPGA. The Basys2 device board is used to implement the FPGA controller. This board uses Xilinx Spartan 3E.The devices to be controlled are connected to this board. The FPGA board is very costly around 125dollars moreover the connection medium used is a wired medium which is less flexible as compared to wireless medium.

Based on this survey we can deduce that a home automation system needs to be cost effective and user friendly. The systems that are mentioned didn't satisfy this constraint. Moreover a wireless means of communication is more flexible then a wired one. So our system holds the novelty in such a way that the FPGA board used in this proposed system is very cheap hence cost effective and provides 48 input output pins hence it offers more connectivity with surrounding devices. This Spartan 3E FPGA offers a Digital Clock manager that will allow us to vary the crystal clock frequency.

III. PROPOSED SYSTEM

A. System architecture

In this paper we have proposed a system for Home Automation which is based on FPGA and Wireless Fidelity (Wi-Fi) and its block diagram is as shown in figure 1.The prime elements of the proposed system are the FPGA controller and the Android mobile. The FPGA controller is connected to an ADC (Analog to Digital Converter), Dimmer module, Wi-Fi module, limit switch and an LPG (Liquid Petroleum Gas) senor and a device driver. The Spartan 3E FPGA used here is a Papilio One 5000k board that consists of IC XC3S500E. The block diagram consists of an ADC to which an LDR (Light Dependent Resistor) and a Temperature and humidity sensors are connected. It is an 8 channel ADC that is, it can support up to 8 different analog sensors. Here we have used two. One is an LDR (Light Dependent Resistor) which is used to sense whether the room's light is on/off. DHT11 is used to sense the temperature of the room. Both these sensors are connected to the controller through an ADC. For the ADC to communicate with the controller, it will need 4 control signals. A Limit switch is used here to indicate whether the room's door is opened/closed. For indicating the gas leakage we have used a MQ series gas sensor. The user uses the Wi-Fi medium for connecting with the controller. On the user side, the Wi-Fi is made available through his Android phone which is then connected to a Wi-Fi module in order to establish a connection with the controller. Here we are using a simple USR Wi-Fi232T module. In order to adjust the speed of the fan or the intensity of the bulb we have used a dimmer module. The device driver IC ULN2803 that amplifies the current is used to drive the loads.

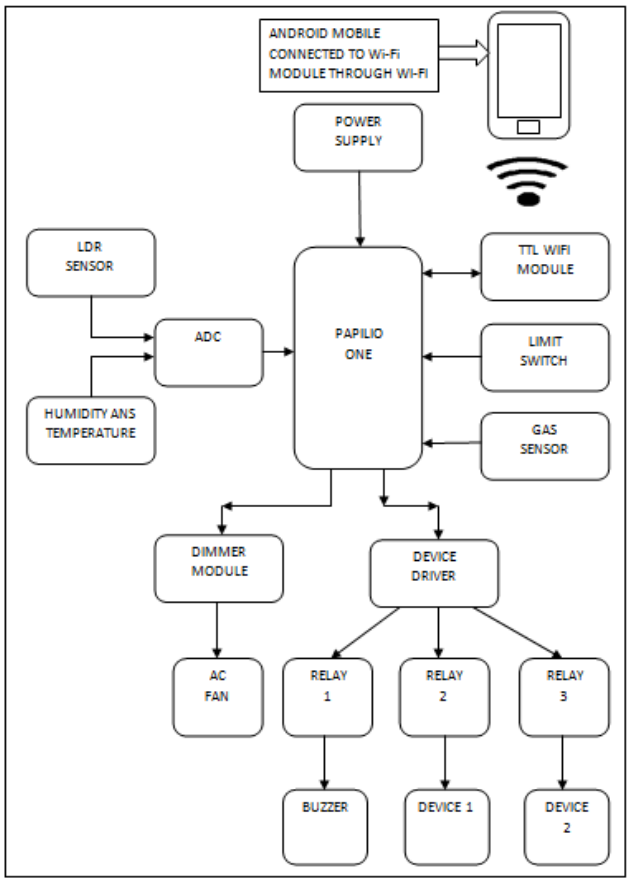

Figure 1. Block diagram of proposed System

B. Workflow

The required flow of the entire proposed system is as shown in the Figure.2. Once the system is powered up the initialization of analog to digital converter and the UART takes place in order to perform the exchange of the data between the controller and user for this reason a Wi-Fi connection is established. Then the temperature sensor is read for its sensed values. The user will set a threshold temperature value through his phone. Then the controller checks this value, if it exceeds the threshold it will turn on the fan in order to cool down the room temperature and it will notify the user regarding the performed action by sending him a text message (SMS) and displaying the same on the application.

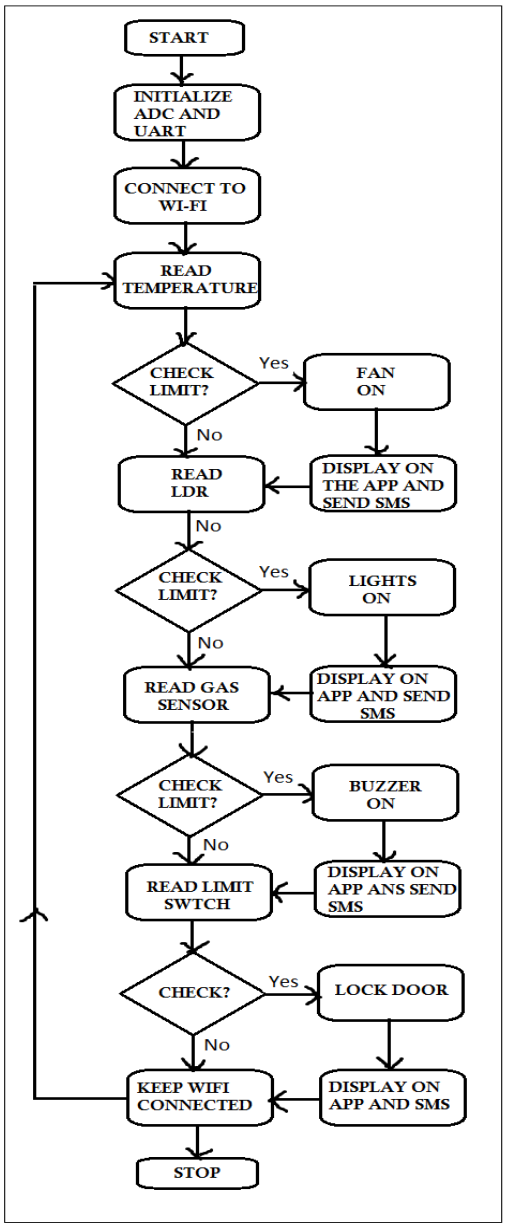

Figure 2. Workflow of proposed system.

If the value does not exceed the temperature threshold value, then the controller reads for the LDR sensor. If the light intensity exceeds the threshold value set by the user then it will turn on or off the rooms light accordingly and notify the user about the performed action. If not the controller will proceed to read for the gas sensor. The threshold limit for the gas sensor is checked and if it exceeds the threshold value the buzzer will be turned on and the user is informed about this emergency. If the threshold value of gas sensor is not exceeded then the controller reads for the value of limit switch. The user has set a value in order to identify the condition of the door that is whether it is closed or opened. If this threshold condition is exceeded or if the door is left opened in that case the controller will perform an action that

will result in the locking of he door and the user is notified about this subsequent action being performed. After performing the necessary actions for the output of the limit switch the controller will again go back to read the temperature sensor values and hence the entire process is again repeated. The Wi-Fi is kept connected as long as the reading of the sensors is performed by the controller. Once done with the reading action the entire system can be stopped by disconnecting the Wi-Fi connection established. Every time the user will be notified about the actions that the controller takes based on the threshold values set by the user by sending him an SMS notification. Apart from the actions being taken in the flowchart, the user can also control the speed of the fan or adjust the intensity of the brightness of a bulb from his phone. This is possible due to the dimmer module being used.

IV. GRAPHICAL USER INTERFACE

In the proposed home automation system for the user to control the appliances through controller he needs a smartphone application that will aid this purpose. This application is developed using Android Studio that is based on JAVA platform. This application encompasses of distinctive tabs to:

1. Activity controlling of devices like fan or bulb.
2. Starting, connection establishment and termination of actions to be taken.
3. Setting of threshold values for the sensing parameters.

V. RESULTS AND DISCUSSION

A. Designed Android Application

The figure 3 shows the screen shot of the developed Android application for the Automatic mode of operation. Here we can see are four different parameters that will be sensed and monitored. These parameters are temperature, humidity, gas leakage and status of the door whether it is locked or left opened.. The values corresponding to these parameters are nothing but the threshold values set by the user as per his needs, once the sensed values exceeds this set threshold the controller will automatically turn on the output devices without concerning the user. The fan speed is variable that can be increased or decreased by using the buttons “UP” and “DOWN”. The “START” will initiate the connection process between the user mobile Wi- Fi and the Wi-Fi module. The “CONNECT” will establish the communication link. The user can terminate with the operation by selecting the “STOP” button.

Figure 3. Automatic Mode

The Figure 4 shows the screen shot of the developed Android application for the Manual mode of operation. Here we control four devices that is light, fan, device 3 and device 4. The “ON” and “OFF” button will allow the user to turn on and turn off the devices from his mobile itself. The “CONNECT” button will connect the user mobile Wi- Fi with the Wi- Fi module. The “DISCONNECT” button will terminate the communication. The “BACK” button will take us back to the Automatic mode of operation

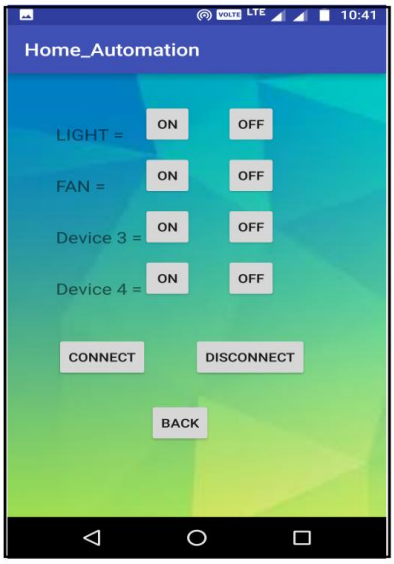

Figure 4. Manual Mode

B. Hardware Model:

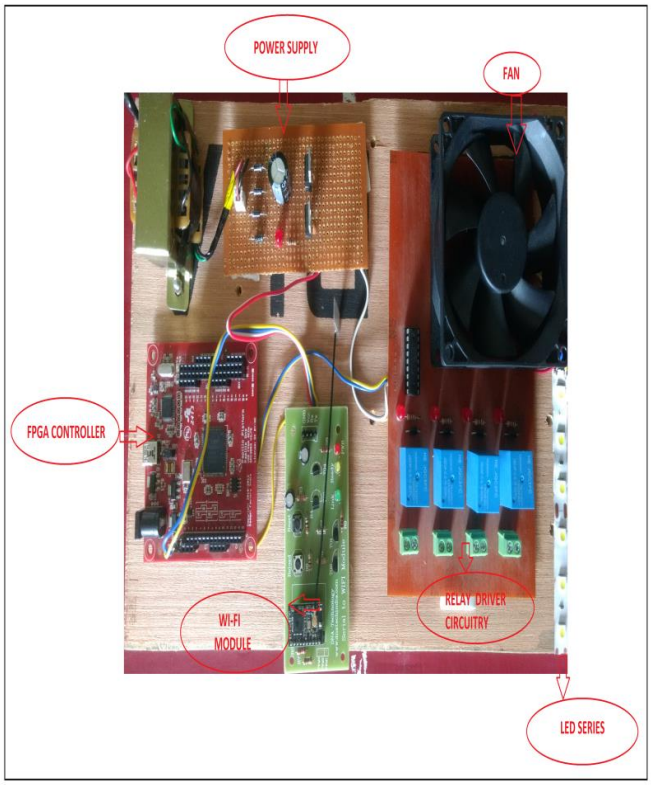

Figure 5. Hardware Setup

The is the hardware setup of the proposed system consisting of a FPGA controller, a fan , a LED series, a power supply, Wi- Fi module and relay driver circuitry is as shown in figure 5. The fan and the LED series are the output loads. Once the generated bit file is dumped onto the IC XC3S500E the communication between sensor and the output loads can initiate. The Fig 4 showing the manual mode of operation is used when we want to turn on the fan or light here LED series in our case, by the user himself irrespective of the sensed temperature and light intensity value.

VI. CONCLUSION

Thus through this paper we saw the implementation of Home Automation with some significant sensors which support to detect and notify any stimuli like fire, motion, intruder, smoke etc. to the host. The computation increased as the complexity of more sensors working in parallel, but FPGA has the inheritable parallelism function which helped to do it sophistically. The use of Verilog HDL language in FPGA is the best alternative to do repetitive function which can be off load onto FPGA.

REFERENCES

[1] Erec, "Home Automation Systems" in Reporter, February, 2002, Vol.19.

[2] "Manfred Schneps-Schneppe, ITU G.hn concept and Home Automation", 2010.

[3] P.A Bawiskar and Prof R . K. Agrawal " FPGA Based Home Security System", International Journal of Innovative Research in science Engineering and Technology, Vol.4, Issue 12, December 2015.

[4] N.Chintaiah, K. Rajasekhar, V. Dhanraj, "Automated Advanced Industrial and Home Security using GSM and FPGA", International Journal of Computer Science and Information Technologies, vol. 2(4), 2011, 1598-1602.

[5] An Braeken, Jan Genoe, Serge Kubera, Nele Mentens, Abdellah Touhafi, Ingrid Verbauwhede, Yannick Verbelen, Jo Vliegen, Karel Wouters, "Secure Remote Reconfiguration of an FPGA based Embedded Systemm", unpublished.

[6] AMohamed S. Soliman, Majed O. Dwairi, Iman I.M. Abu Sulayman, Sami H.A. Almalki, "Towards the design and implementation of a Smart home automation system based on Internet of Things Approach ", International Journal of Applied Engineering Research, ISSN 0973-4562, Vol 2, No:11 (2017), pp. 2731-2737.

[7] Sweatha K N, Poornima M, Vinutha M. H. "Advance Home Automation using FPGA controller", International Journal of Advanced Research in Computer and Communication Engineering, Vol.2, Issue 7.