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Intelligent Energy Management System based on FPGA and GSM

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Abstract: ***The concept of intelligent home automation has been an interesting topic for researchers and practitioners during last few years. Home automation is adopted for reasons of ease, security and energy efficiency. This paper presents a cost effective solution that uses FPGA controller at the core system based on I2C protocol which provides easy communication between slave memory and FPGA that issues all the programming controls required for Home Automation System. This paper explains the hardware and software design method adopted covering the complete design flow to design embedded product.***

Keywords: FPGA, GSM, I2C, HAS

1. Introduction

The "Home Automation" concept has existed for many years. The terms "Smart Home", "Intelligent Home" followed and has been used to introduce the concept of networking appliances and devices in the house. It is becoming popular nowadays and enter quickly in this emerging market. Home automation Systems (HASs) represents a great research opportunity in creating new fields in engineering, architecture and computing. It is adopted for easy handling, security and energy efficiency. User needs, a home that satisfy variations from basic requirements to external and internal aesthetics and provide a secure comfort at home.

Due to the advancement of wireless technology, there are several different of connections are introduced such as GSM, WIFI, ZIGBEE, and Bluetooth. Each of the connection has their own unique specifications and applications.[7] Among the four popular wireless connections that often implemented in HAS system, GSM is being chosen with its suitable capability. The system intended to control electrical appliances and devices in home with user-friendly interface and ease of installation. To design this embedded product the paper also explains about the hardware and software design method which contains tools chain and techniques.

2. Related Work

A lot of work has been carried out in this field of communication related to smart home. The concept of intelligent homes has attracted the attention of a number of researchers and practitioners during the last years. Most of these current techniques focus on using wireless communications to communicate with the home appliances.

In this paper author has discussed that it is a cost-effective solution that uses a Field Programmable Gate Array (FPGA) controller at the core of the system to provide the intelligence for the home system. Moreover, the controller interfaces to a mobile device through the GSM Modem. Communications port to allow monitoring, configuration, and switching of devices.[1]

Sweatha K.N.,Poornima M. and Vinutha M.H in In this [2] presents a novel technology where the user controls the devices through mobiles. Implementation is done using FPGA (Field Programmable Gate Array) as a controller to which the devices are directly interfaced. Control to the devices is communicated to the FPGA from the mobile phone using speech recognition technique.

This paper presents the design and implementation of a low cost but yet flexible and secure cell phone based home automation system. The design is based on a standalone Arduino BT board and the home appliances are connected to the input/ output ports of this board via relays. The communication between the cell phone and the Arduino BT board is wireless.[3]

Ming yan and Hao shi in [4] discusses about a new Smart Living system called home lighting control system using Bluetooth-based Android Smartphone is proposed and prototyped. First Smartphone, Smart Living and Bluetooth technology are reviewed. Second the system architecture, communication protocol and hardware design are described. Then the design of a Bluetooth-based Smartphone application and the prototype are presented. It is shown that Android Smartphone can provide a platform to implement Bluetooth-based application for Smart Living.

3. Methodology

In this section the block diagram is discussed. The Figure 1 shows the block diagram of home automation system .The process is designed in Verilog language for HAS using Xilinx 14.1. The proposed block dia. shown as below which contains sensors, intruder circuit with FPGA.

Cellular phone consists of SIM (Subscriber identity Module) card. It contains a unique number. Radio frequency is the communication link between the device and GSM modem.

The FPGA can be used to implement any logic function. The Spartan R-3 family of Field-Programmable Gate Arrays is specifically designed to meet the needs of high volume, cost-sensitive consumer electronic applications. The eight-

member family offers densities ranging from 50,000 to 5,000,000 system gates.[5] These Spartan-3 FPGA enhancements, combined with advanced process technology, deliver more functionality and bandwidth per dollar than was previously possible, setting new standards in the programmable logic industry. Because of their exceptionally low cost, Spartan-3 FPGAs are ideally suited to a wide range of consumer electronics applications, including broadband access, home networking, display/projection and digital television equipment.[1]

A GSM modem is a specialized type of modem which accepts a SIM card, and operates just like a phone. When a computer is connected to GSM modem, it allows the computer to use the GSM modem to communicate using mobile network. [6] The communication between user and home is established by dialing a no. of owner. It is an efficient way to design a Home Automation system using GSM modems. GSM modems are cost effective solution to send and receive SMS messages and calling also. RS 232 serial port is used to establish communication between the system and host computer. It is better to use GSM Modem, instead of Cell phone as it limits the hardware functionality. In the proposed system, SIM 800 GSM modem is used. It works on frequencies 850 MHz, 900 MHz, 1800 MHz, 1900 MHz. The baud rate can be configurable from 9600-115200through AT command. Initially Modem is in auto-baud mode.[5][6]

The interfacing unit consists of sensors, fan, and LED (Light emitting diode). Relay is connected to LED and fan. 9V battery is used to energize the relay and other two devices. The programmed FPGA is connected to interfacing unit and GSM modem through serial port of the GSM modem. The sensors used in interfacing unit and allow the central FPGA controller to make decisions. Firstly I2C is implemented over FPGA. [9]

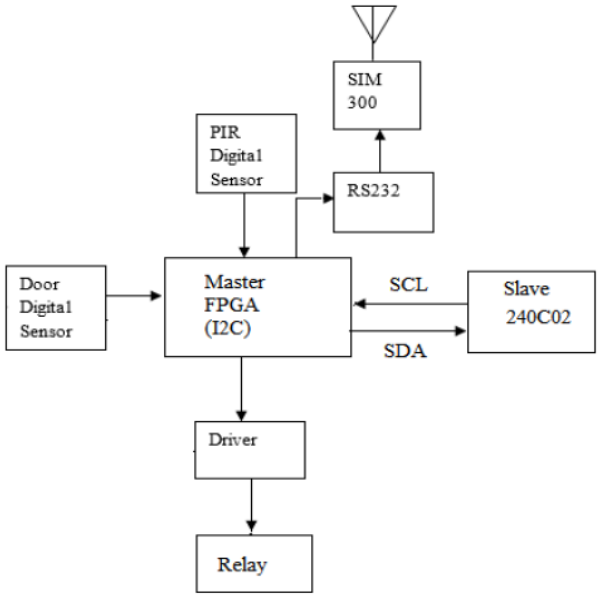

Figure 1: Block Diagram

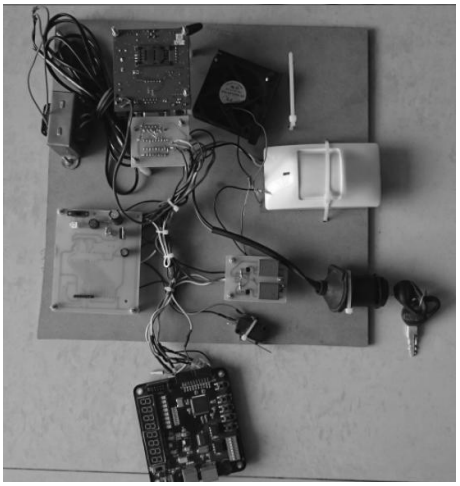

Figure 2: Experimental Set up

4. Results

The below figure is simulation result of I2C protocol. It is designed using Verilog and implemented in Xilinx 14.1. Also device utilization summary is given below:

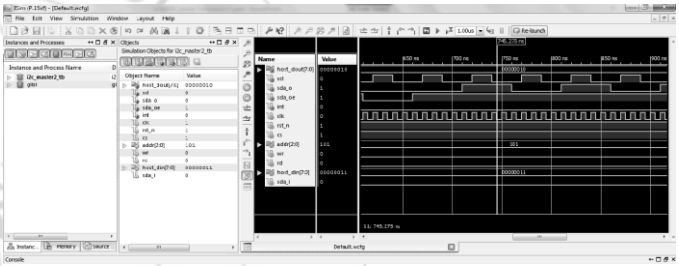

Figure 3: Simulation result of serial communication

Here the software part is designed using verilog and implemented in Spartan 3 xc3s200a using xilinx 11.4. The device utilization summary is given below:

Table 2: Device utilization summary

Logic Utilization	Used	Available	Utilization
Number of Slice Flip Flops	113	3584	3%
Number of 4 input LUTs	133	3584	3%
Number of bonded IOBs	12	68	17%

5. Conclusion

In this paper, design and implementation of a low cost, flexible and wireless solution to the home automation is introduced. The implementation of home automation using FPGA is achieved. The FPGA was selected as, compared to microcontrollers, it provides a larger number of input/output ports and faster algorithm execution. This leads to a low cost system that can be easily scaled up. As it uses GSM interface the system can be used in remote areas also. The system provides security of the home with a observance of PIR sensor, temperature sensor, etc. In future it can be Extended to different home appliances and automatic controlling of them, and also in different areas of industry .This can be useful for automated switching of the devices. The system is secured for access from any user or intruder. This system can be used as a test bed for any appliances that requires on-off switching applications

without any internet connection. The full functionality of the home automation system was tested.

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