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Effective Replacement of FPGA for Microcontrollers in Home Automation

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Abstract

Nowadays the Home automation is a demanded Application / project of every class of people to make their life dynamic and secure. Most of these Home automation systems are developed using Microcontrollers with the help of various sensors to monitor the home Appliances, as most of the sensors are not robust in physical structure , as well as Microcontroller based systems has the disadvantage of limited number of ports (limited Appliances) Fixed Architecture, less speed, not extendable / modifiable to add new devices. Keeping this in view, we are presenting a Cost effective Home Automation system, which replaces the role of Microcontroller with an FPGA and a wire throughout Panel Electrical Boards in the House which carries the Data instead of sensors and data convertors.

In this work each port of FPGA represent to a Room/ Area, and every device is controlled through an 8 bit data sent over the GSM. GSM (Global System for Mobile communication) network is used to establish the communication between the users mobile and the FPGA. The design described in VHDL and implementation has utilized less devices on FPGA. The total system is tested with a real time prototype consisting of 5 devices and found accurate and cost effective.

Keywords: Home automation; FPGA; GSM; Spartan 3AN; VHDL; VLSI.

INTRODUCTION

Home automation mainly controls Home appliances remotely and affords safety, while the owner is far from the vicinity. This system affords the perfect option to the troubles faced by means of owners in each day life. The motivation is to facilitate the users having regularly occurring get right of entry to automate their houses. Which allows the users to set the Home environment according to their personal needs. By using Home automation systems once can control Home appliances such as turn OFF the light that is still ON In the kitchen or turn ON the air conditioner on the way Home. Current Home automation systems are based on various techniques such as Bluetooth, ZigBee integrated with a Wi-Fi network, Internet, Java based 3D visual interface etc. are discussed as follows.

The concept of intelligent homes has attracted the attention of a number of researchers and practitioners during the last years. Most of these recent techniques focus on exploiting wireless communications to communicate with the devices. In [2] the authors introduce the idea of using Bluetooth as a cable replacement for home automation. However, no implementation details are given. An automation system based on Bluetooth was developed in [3]. It consists of a remote and a mobile host controller that communicates with several devices representing the home appliances. A similar solution was presented in [4], where a Bluetooth multihop mesh topology was used to relay sensor node information to a mobile phone or a personal computer.

A Zigbee based home automation system was integrated with a Wi-Fi network through a gateway in [5]. The gateway provides the user interface and accessibility to the system. The system was evaluated using four devices. A similar approach was taken by the authors in [6], where the design of an architecture integrating a Zigbee home network into the Open Service Gateway initiative (OSGi) framework-based home gateway is presented.

Techniques that use Internet as the means for home automation have also been proposed. A system based on an embedded controller which is interfaced via an RS232 port to a personal computer web server was presented in [7]. The controller is then connected to the appliances and sensors. The Internet access allows both local and remote access to the home system. A system using the Global System for Mobile communications (GSM), Internet, and speech recognition, was proposed in [8] for real-time monitoring and remote control of the home appliances. This adds flexibility to the system, however, it increases the cost when using GSM technology.

The authors in [9] try to improve the Graphical User Interface (GUI) of the home automation system by introducing a 3D visual interface. The aim is to enhance the user experience and allow faster take up of such technologies. This system also exploits Internet to allow dwellers to control and monitor the home from outside.

All of the above systems has disadvantages because of limitations in using microcontrollers like fixed architecture, less number of ports, low speed, less durable. So to overcome all these problems we have presented Home automation system that provides availability to develop a low-cost solution which is affordable and allows Home security the ease of deployment is due to the wireless communication. Here GSM module is a bridge responsible for enabling / disabling of SMS capability. The house automation system is designed the use of FPGA controller in the middle to offer sensible Home solutions. The controller interfaces to a mobile device through GSM network to allow monitoring and controlling of the devices. This system can be used anywhere, as long as it in the range of phone network is available.

The paper is organized as follows. Section II briefly explain

Home automation system in which includes system architecture and working principle and section III describes the experimental results of the proposed architecture. Section IV discuss the conclusion. At last references that which were referred for the implementation.

HOME AUTOMATION SYSTEM

The proposed system takes the home automation to a new level. This system will remove all the sensors and overcome the limitations of using microcontrollers. Here each of the output port of the controller can able to operate a whole room of having at most 5 devices based on the input data. By using this system one can control Home appliances such as turn OFF the light that is still ON In the kitchen or turn ON the air conditioner on the way Home. So the system affords a perfect option to the issues confronted by owners in daily life. This will happen just by installing a wire for each room from the main power supply. Which makes the system low cost and more robust.

II (a). System Architecture: The architecture of the system mainly consists of four components GSM modem, FPGA Controlling unit, interfacing unit as shown in Figure. (1).

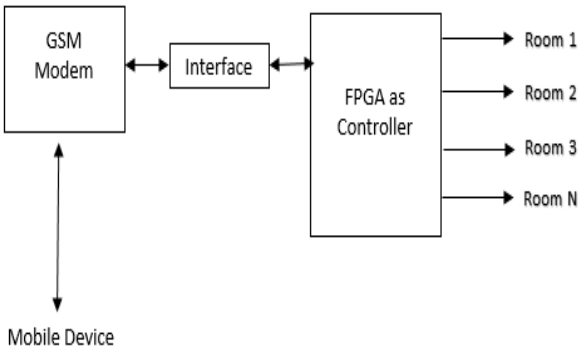

Figure 1. Block diagram of Home automation system

The central FPGA controller is connected to the interfacing unit and the GSM modem through the serial port of GSM modem. By using Xilinx ISE software to program FPGA controller and control according to the interrupt in the form of a message which is sent by GSM modem.

The GSM modem consists of a SIM slot to insert SIM card having a unique number for communication over telephone network. Serial port is available to communicate with external hardware. AT commands are used to send/read SMS or to make/take calls from the GSM modem. The communication between GSM and FPGA Controller take place via the RS232 serial port. (A cell phone can be connected at the place of GSM hardware however it limits the hardware functionality inclusive of sending or receiving).

The FPGA is a programmable digital logic chip. It has internal RAM and can be used to control multiple input and output ports that can be connected to various devices/ appliances. As it is Reprogrammable the new devices can be added at any point of time.

Here in this system Xilinx Spartan 3AN FPGA board is used. Each port of this FPGA is connected to the electrical panel of a room/area through a wire which carries data bits to the serial to parallel port at the panel. The "N" number of output bits of serial to parallel port are used to drive the N number relays which intern controls the "N" appliances / devices connected. As each of the device in a home is working on High AC/DC loads relays are used as interface between switches and ports. All the controlling devices were connected to FPGA controller board. The programmed Spartan 3AN FPGA board is connected to GSM modem through the RS232 serial port of the GSM modem (Input section) and interfacing unit (Output section). User can send an 8 bit data as an input to the GSM that will be converted into serial and send to the FPGA via RS232 link. FPGA sends the 8 bit data through an output port to the interfacing unit by following the algorithm. In the received 8 bit data which ever the bits are enabled according to that respective devices will be operated and also Door Close/Open is being done by a stepper motor. Each of the output port of FPGA can able to control a whole room of having at most 8 devices (if we want we can extend to N number of devices). This has been done by using a serial to parallel convertor between the FPGA and the Interfacing unit. The proto type is practically implemented and tested.

II (b). Working Principle: The main principle here is, FPGA is programmed such that it should connect with GSM using UART interface, and also it take a 8 bit data as input from the external mobile and operate the appliances inside the room according to the message.

Most of the modules were developed using Finite State Machines (FSM). The UART required for the GSM interface was developed using a transmit unit and a receive unit. The transmit unit consists of the Tx module which does the transmission, the Data to Send module that passes the data to be sent to the Tx, and the clock divider module which determines the baud rate. The state machine for the Tx module is shown in Figure 2. The Tx module starts in the Wait for Data state where it waits for the data to become available in the Data to Send module. Once data is present, the enable bit is set and the state moves to send. At this point data is transmitted starting from the Least Significant Bit (LSB). Eight bits of data are sent at the selected baud rate encapsulated between a start and a stop bit. When this frame is sent, the state goes back to Wait for Data to get the second frame which completes the packet to be transmitted. When the two bytes of data are sent the state goes to RST to reset the registers and send an acknowledge signal to the Data to Send module. The enable bit is then cleared and the process starts again in the Wait for Data state. The Data to Send module is responsible for acknowledgments that are sent to the GSM to confirm that a command has been executed. The module is initialized in the Waiting state where it listens for data coming from the system module. Once data is sensed, the state moves to Send which sets the enable_out bit to inform the Tx unit. When the Tx unit

acknowledges the data, the state moves to RST where the system module is informed that the data has been sent.

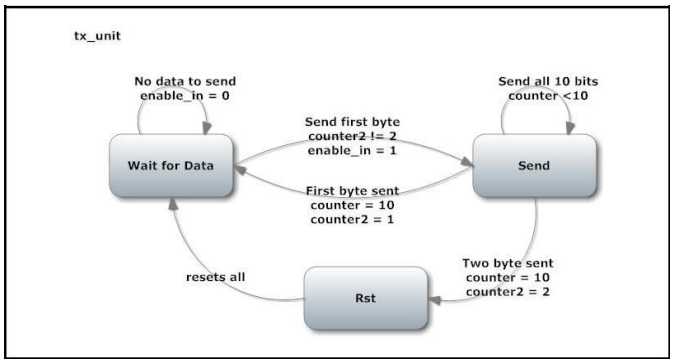

Figure 2. The Tx Finite State Machine

The state machine for the receiver module (Rx) is shown in Figure 3. Initially the FSM is in the Wait for start bit state where it waits for the start bit. On reception of this bit, the system moves to the Receive byte state. Data is acquired during this state, where sampling is done at the middle of each data period controlled by a counter. When the stop bit is correctly sampled, the system moves to the Store byte reset state. If this is the first byte it is stored and the system returns to the initialization state to wait for the second byte. When the second byte arrives, data is sent to the Rx separator module, which stores the data. The enable_out bit is set to signal that data has been received can be processed. The sixteen bits of data together with the Data ready signal are also sent to the system module.

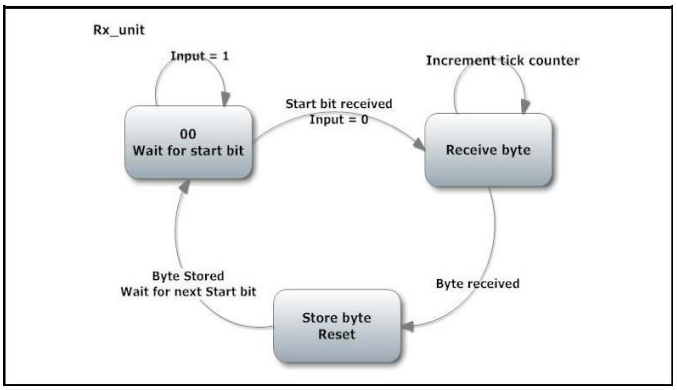

Figure 3. The Rx Finite State Machine

The system then resets the clock counter and returns to the initial state. The baud rate used for this serial transmission is 9600Hz. A clock divider had to be implemented as the on-board clock operates at 50MHz.

The received 8 bit data is used for selecting the output port. Here each port can operate a whole room of having at most 5 devices, and also for selecting the appropriate device inside the room.

EXPERIMENTAL RESULTS

Here Xilinx Spartan 3AN board is used as central FPGA controller, to control the Home appliances when the user is out of station. The Room unit consists of Relays which are connected to Bulbs also to a Stepper Motor. The relay is connected to make and break the connections. The system module controls all the modules implemented on the FPGA board. As soon as data from the mobile phone reaches this module through the Rx module, where it is interpreted and a decision is made accordingly. If the state of an appliance is modified, this module sends an acknowledgement to the GSM modem via the Tx module. The system is made such that by sending an 8 bit data to the GSM to operate the appliances in the room.

Connection details are given below:

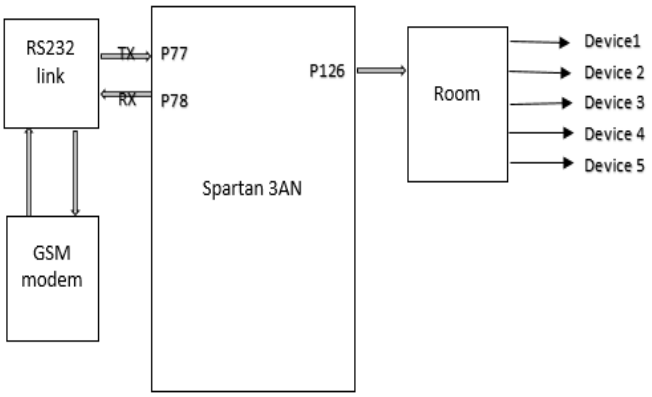

Figure 4. shows the connection between GSM modem and Spartan 3AN board through interfacing unit and FPGA to Rooms / panel boards.

The central controller was implemented on a Spartan 3AN development board, which uses a Xilinx Spartan-3A FPGA. The hardware inside the FPGA was developed using the Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL). A modular approach was taken such that the design and test phases are simplified and scalability is facilitated.

Finally the GSM module has a SIM card inserted the operate the devices like ON/OFF the relays or Door lock/open using stepper motor done by sending 8 bit data / address to the GSM. The received SMS is compared with the control characters those are there in the FPGA memory. So whenever the 8 bit data received at the FPGA then after it will choose the room and then it can operate up to 5 devices in that room. The total system is tested with a real time prototype consisting of 5 devices and found accurate.

Figure. 5 (a) shows the image of Home automation system with user's mobile, in which user sent SMS to GSM as "VWXYZ" (without quotations) to turn ON all the devices. As soon as GSM modem receives SMS, all the devices will get turned ON.

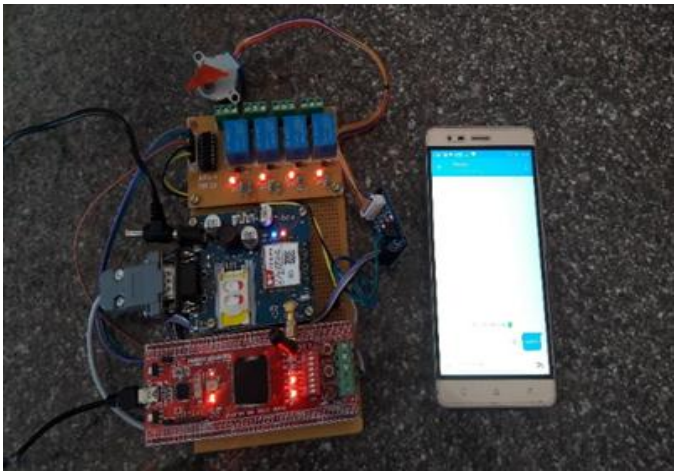

Figure 5(a) all devices are ON

Similarly Figure. 5(b) shows the image of Home automation system with user's mobile, in which user is sending SMS "vwy" (without quotations) to turn OFF stepper motor, LED1 and LED3. As soon as GSM modem receives SMS, all the devices get turned ON.

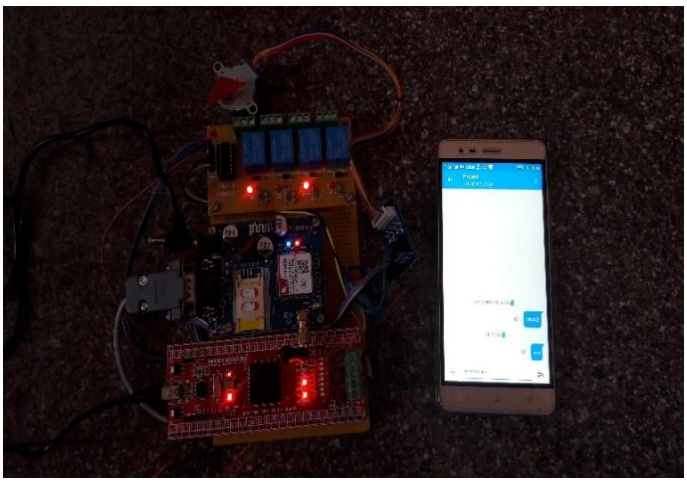

Figure 5(b) some devices are OFF

In the same way, user can send "vwxyz" (without quotations) to turn OFF all the devices. We can also control individual devices to turn ON and OFF.

CONCLUSION

The Home Automation using FPGA controller via GSM introduces a new level of Home Automation system. One can operate the entire home just by installing a wire from the main power supply (as similar as an inverter wire). The main intension of this project is the gate occupancy on the FPGA is very less, we are planning to design a new IC that has built in GSM and having only the required number of ports to control the home. If that is the case users can buy the IC and serial to parallel connectors then install wires from the FPGA to rooms which is of low cost will make their home completely automatic. The system is appropriate for real-time monitoring and controlling of various domestic appliances. Furthermore, pairing allows some level of security to avoid network intrusion. Finally system has many advantages consisting of the controlling variety of Home accessories from anywhere, availability and simplicity of use, low of cost, also if we extend of home we can easily use the same system for both houses means one can use this single system to secure more than one home like an entire apartments because of the availability of many I/O ports which leads to operation of an entire apartment with easy to use at very low cost.

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