FPGA Implementation of Controller Design for Remote Sensing Systems

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Abstract

Remote Sensing today needs to make use of the latest available technological components. In this paper, we present the design and hardware implementation of the main controller for a remote sensing system that can be communicated through the GSM (Global System for Mobile) network. This system offers a complete, low cost, powerful and user friendly way of 24 hours real-time monitoring and remote sensing system. The design has been described using VHDL (VHSIC Hardware Description Language) and implemented in hardware using FPGA (Field Programmable Gate Array).

Keywords: FPGA, GSM, VHDL, Controller, Remote Sensing.

1. Introduction

Home Automation systems are commonly found in electronic form today. A system of sensors is connected to a controller, which in turn connects to a GSM [1-3]. Remote sensing has many applications in real life; one of these applications is for home automation [4-6]. We are introducing the design of a controller with low cost and large number of inputs and outputs that can be used either for controlling or sensing the remote devices. The system is based on designing and implementing an FPGA chip that is interfaced with a GSM MODEM to work together as a remote sensing and control system at the same time [7-13]. The hardware of the controller chip has been designed using VHDL and has been tested using Xilinx FPGA [14-20]. First a synthesizable VHDL code has been written and simulated using Xilinx ISE 6.2i tools, and then implemented on a Xilinx Spartan 3 FPGA. The design has been successfully simulated and tested for both sensing and controlling purposes at different frequencies (4800 KHz, 9600 KHz, and 19200 KHz). This section of the article gave an introduction to the presented work; the next section gives some details about the system architecture and operation, in section 3 we are giving some details about the RTL schematic of the design and simulation results, at the end conclusions about the work done will be given in section 4.

2. System Architecture and Operation

The architecture of the system mainly consists of three main components as shown in Figure .1, the controller, GSM, and the remote devices and sensors. The GSM connected to the controller through the RS232 serial communication standard; the controller connected to the different types of sensors and devices. An interface circuit has been designed which includes sensors as input devices and 220 volt lamp as an output devices which represents the controlled devices. Then the controller has been connected to the interface circuit and the GSM MODEM through the serial port of the GSM MODEM. The controller consists mainly from three components; the Control Unit (CU), ROM, and UART (Universal Asynchronous Receiver Transmitter). The VHDL code also includes a communications through the AT commands of the GSM MODEM.

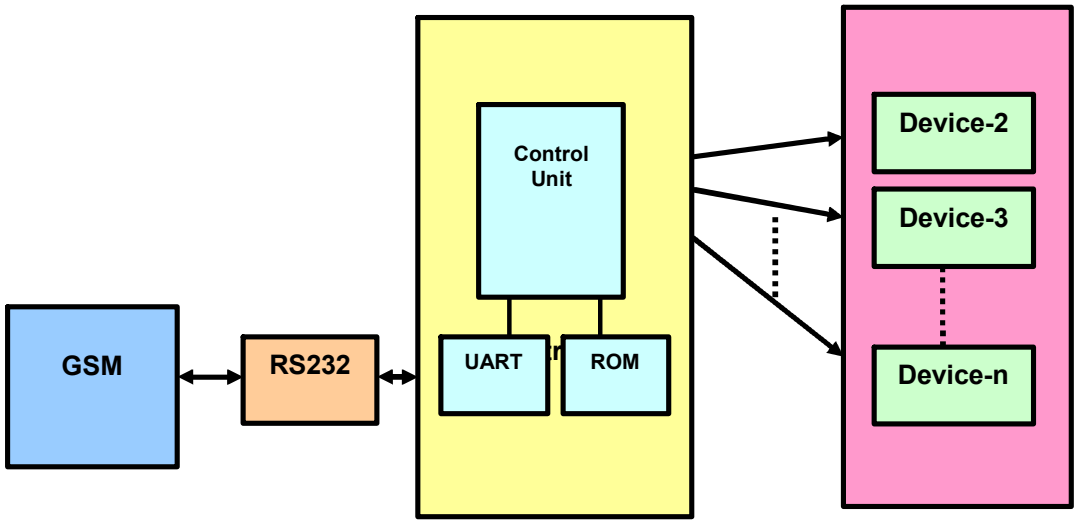

Figure (1) System Architecture

The main function of the control unit is sending AT commands to GSM and checking for new messages from the GSM. The UART has two components, UART transmitter and UART receiver, the main function of the UART transmitter is converting the processed data from parallel to serial, and then sending the serial data to GSM modem, the transmitted data could be an AT command, SMS message to the user, phone call to the Police station, or phone call to the fire brigade in case of home automation. The UART receiver converts the serial stream of received bits into parallel data to be recognized by the control unit. The ROM stores the user telephone number, AT commands, and ASCII code characters. In case of remote sensing 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 Mobil Phone, at the same time the user can send an SMS message to control the devices at the remote place, for example turning on the AC before returning home. The system can work as a Remote Sensing for the electrical appliances at home to check whether it is on or off, at the same time the user can control the electrical appliances at home by sending SMS message to the system, it can also work for remote sensing for climate control. It also works 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.

3. RTL Schematic and Simulation Results

The system has been experimentally tested for both sensing and controlling purposes first with serial port of the PC, then in a real time using Maxon GSM. Figure .2 shows the first sheet of the generated Register Transfer Level (RTL) schematic of the control unit, as the design drawing split horizontally into seven sheets as shown in the figure. Figure .3 shows the simulation for the Control Unit which sends parallel data to UART Transmitter; the parallel data represents the ASII code for the characters; the character could be a message or an AT commands. In the simulation we show the transmitted data in the form of characters but in hardware implementation it is stream of bits that represent the ASCII codes of the characters. In figure .4, the simulation results for a 16*8 ROM is shown in which the stored data represent the ASCII code the decimal number (0, 1, 2, …, and 9) and the rest of the locations contain the alphabetic (A, B, C, D, E, and F).

Figure (2) Register Transfer Logic for the first sheet of the Control Unit

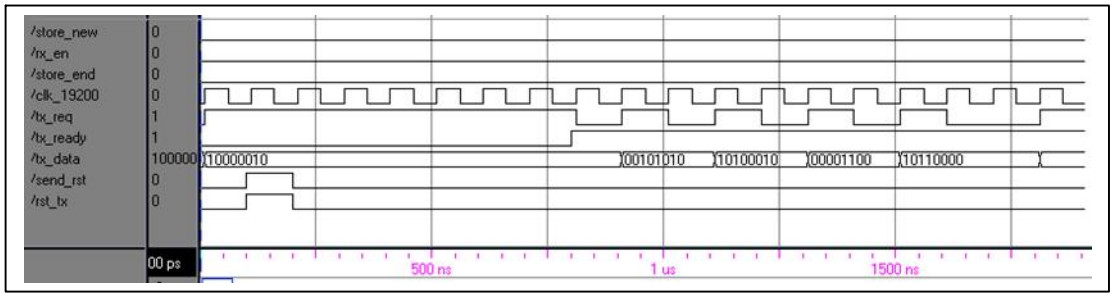

Figure (3) Simulation Results for the Control Unit

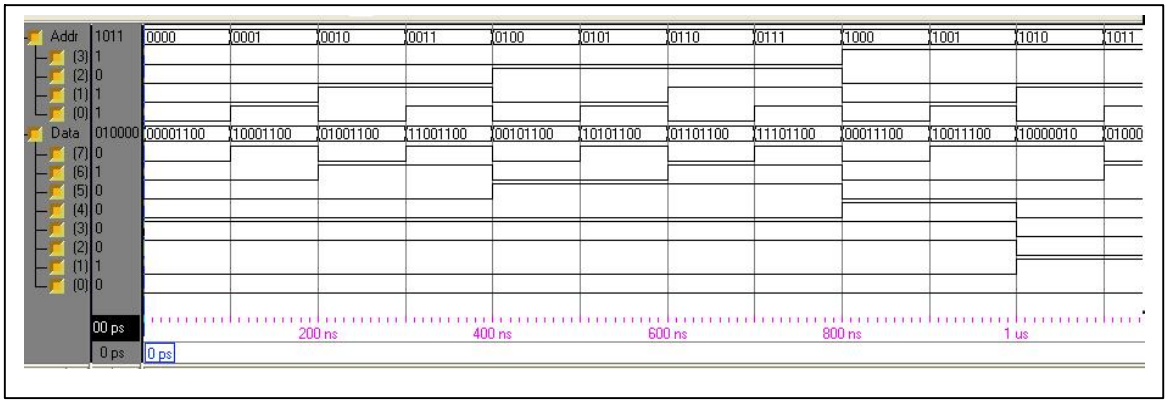

Figure (4) Simulation Results for the ROM

4. Conclusions

In this paper we have introduced a controller design for a remote sensing system based on using FPGA and Global System for Mobil (GSM). The system is suitable for a real time monitoring in home security as well as controlling and sensing in home automation with large number of controlled devices. The system has been design and implemented in hardware using VHDL language and Xilinx Spartan 3 FPGA. Maxon GSM has been used for testing the circuit either for the sensing part of the circuit or the control part. The design was simulated and tested in a hardware level and verified the correctness and working operation of the whole system.

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