

Cost Effective Smart Home Based On Fpga

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Abstract — The houses of 21st century are about to become more human control and automated. The automation is upon us in a huge way and people are rapidly inventing new gadgets that enhance our lives. In the automation advancements, implementing the embedded systems for the purpose of home automation has led to an increase in the security and remote controlling of the appliances at home. The home automation system based on Field Programmable Gate Array (FPGA) Spartan is proposed to overcome the disadvantages of using Microprocessor and Microcontroller. FPGA is used as a core, instead of microcontroller, because of its flexibility, increase in better power efficiency and decreasing prices. This system is based on SMS technology and uses GSM network to establish the communication between mobile and controller. GSM system uses TDMA technique for communication purpose. Once the message is sent to GSM Module, it transmits the mobile voice and data services at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. FPGA Spartan receives input through I/O blocks and it transmits to GPIO Pins, which is connected to the load, lamp etc through driver circuit. This System is designed using VHDL in Xilinx 14.7 which is implemented in FPGA Spartan.

Index Terms - *FPGA, Spartan, Smart Home, SMS, Mobile, GSM*

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. 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. The concept of “smart House” was introduced in late 1984 by National Association of Home Builders (NAHB). 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. Hence, a system to automate the house and make it smart is proposed in this paper.

The rest of the paper is organised as follows. The next section discusses the architecture of FPGA. Section III presents the Literature survey on the existing FPGA based home automation systems. Section IV discusses proposed system architecture. Section V deals with the simulation result of the proposed approximation. Finally conclusions are drawn in section VI.

II. AN OVERVIEW OF FPGA

Field Programmable Gate Array (FPGA) is a type of Integrated Circuit (IC) that will facilitate its user to create his own design and program it after it is manufactured. Basically an FPGA is like a blank state that means designer can create their very own configure file or bit file. The bit file that is loaded onto the FPGA will act as a digital circuit that the designer aimed to design. The FPGA does not has a processor to run the software until the designer builds one, it is up to the designer to create a simple file like an AND gate to multi core processor . The configuration of an FPGA needs a Hardware Descriptive Language (HDL). The utmost important block is primary block that builds up an FPGA is Programmable Logic Block (PLB) which are programmable and are utilized to replicate the functions of logic gates. This logic block can similarly be assigned the function to act as computer memory which permits to store certain values and also between this logic blocks there are reconfigurable wiring circuitry. The FPGA logic block consists of a 4 input LUT (Look up Table), a programmable multiplexer which assists to choose whether the FPGA be programmed in registered or non -registered output and finally a flip-flop for storage. FPGA is a volatile device.

III. LITERATURE SURVEY

P.A. Bawiskar and Prof. R. K. Agrawal [5] featured a project that is a combination of VHDL features with sensor based circuitry for alarming and detection purpose. The IR Transmitter and Receiver pair that are well suited for the object detection purpose. This detected result is given to FPGA which is connected to computer along with a GSM Modem. PC scans the sensor status and

provides to mobile. Matlab coding is used to display the status of sensors or to start/stop the messaging.

N.Chintaiah, K. Rajasekhar, V. Dhanraj [6], have presented an Automation system based on GSM that can be used for Industrial as well as for Home Automation purpose based on a Distributed Control Application platforms. System is implemented using Nexys2 circuit board based on Xilinx Spartan3 FPGA. Interface circuit will include sensors acting as input device and 220V lamp as output device which represents the device to be controlled like TV, AC and Fan etc. Thus FPGA is programmed and connected to GSM modem and Interface circuit.

Chandrashekhara Rayi, R. V, Krishnaiah [8] have implemented the concept of Home Automation with the aid of RF Module and FPGA for increasing the range of communication. The Xilinx ChipScope tool package is used here that has many modules that could be added to the VHDL design to capture output. This tool will also capture the input which is straight from the FPGA board.

Mohamed S. Soliman, Majed O. Dwairi, Iman I.M. Abu Sulayman, Sami H.A. Almalki [9] with the help of Internet of Things have implemented the Home Automation architecture that works in Wired as well as Wireless configurations. There is an interface circuit that has been connected to the output appliance and with the sensors as well and this module is further connected with the FPGA controller.

Sweatha K N, Poornima M, Vinutha M. H. [10] 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 microcontroller does this job and passes this data further to the FPGA. Here what the user desires to control is a DC motor, Stepper motor and a Light Emitting diode which comprise to represent the output side.

IV. PROPOSED ARCHITECTURE

In this paper, a system is proposed which uses GSM (Global System for Mobile communication) network to establish the communication between mobile and controller. The system is based on SMS (Short Messaging Service) technology. The design is based on using VHDL and implemented using hardware using FPGA. Fig. 1 shows the block diagram of proposed architecture.

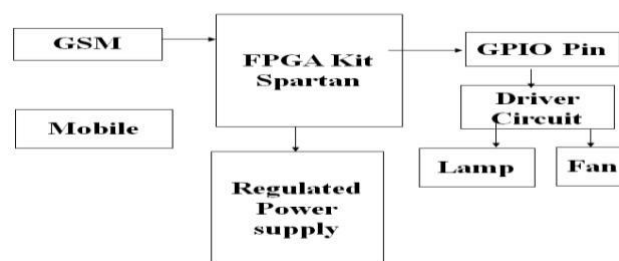


Fig. 1: Block diagram of proposed architecture

V. SYSTEM COMPONENTS

The list of modules required for the implementation of the proposed system are Spartan kit, GSM module, Relay, Driver circuit, Detector, Regulated Power supply, UART(Universal Asynchronous Receiver Transmitter).

1. Spartan-6 XC6LX16-CS324:

It is an open source FPGA development board that is based on Xilinx Spartan 3E FPGA. It consists of Type-A USB host for mouse, keyboard, or memory stick 8 slide switches, 5 push buttons, 4-digit 7-segment display, 8 LEDs, Four double-wide Pmod ports, One 40-pin VHDC connector and 8-bit VGA. It also consists of 16Mbyte Micron Cellular RAM, 16Mbyte Micron Parallel PCM and 16Mbyte Micron Quad-mode SPI PCM. A 100 MHz fixed-frequency oscillator is provided to this board that can be converted to any speed desired inside the FPGA using Digital Clock manager.

2. GSM:

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. The communication between user and home is established by sending and receiving the SMS protocol. A GSM modem uses AT (Attention) commands to send, receive messages. It is an efficient way to design a Home Automation system using GSM modems. It can be a quick way to get started with SMS, because no special subscription to an SMS service provider is required. GSM modems are cost effective solution to send and receive SMS messages In the proposed system, SIM 900 GSM modem is used. It has Quad-band GSM engine, works on frequencies 850 MHz, 900 MHz, 1800 MHz, 1900 MHz. It is very compact in size and easy to use. In Asian countries 900MHz and 1800 MHz frequency band is used.

3. Relay:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits. The link is magnetic and mechanical.

4. Driver circuit:

The ULN2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single D Darlington pair is 500mA. The Darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers, and logic buffers. The features are 500mA rated collector current (Single output), High-voltage outputs: 50V, Inputs compatible with various types of logic. Fig.2 shows the pin diagram of ULN 2003.

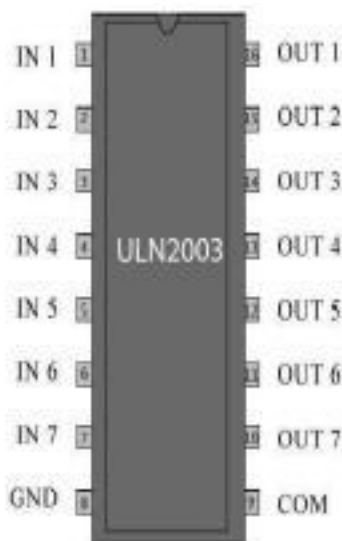


Fig.2: Pin Diagram of ULN 2003

5. Rectifier:

A dc level obtained from a sinusoidal input can be improved 100% using a process called full wave rectification. Here in our project for full wave rectification we use bridge rectifier. From the basic bridge configuration, we see that two diodes (say D2 & D3) are

conducting while the other two diodes (D1 & D4) are in off state during the period $t = 0$ to $T/2$. Accordingly for the negative cycle of the input the conducting diodes are D1 & D4. Thus the polarity across the load is the same.

6. Filters:

In order to obtain a dc voltage of 0 Hz, we have to use a low pass filter. So that a capacitive filter circuit is used where a capacitor is connected at the rectifier output & a dc is obtained across it. The filtered waveform is essentially a dc voltage with negligible ripples & it is ultimately fed to the load.

7. Regulators:

The output voltage from the capacitor is more filtered & finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations, load variations & temperature changes. Here we use fixed voltage regulator namely LM7805. The IC LM7805 is a +5v regulator which is used for microcontroller.

8. UART:

UART stands for Universal Asynchronous Receiver/Transmitter. It's not a communication protocol like SPI and I2C, but a physical circuit in a microcontroller, or a stand-alone IC. A UART's main purpose is to transmit and receive serial data. A universal asynchronous receiver-transmitter is a computer hardware device for asynchronous serial communication in which the data format and transmission speeds are configurable. The electric signalling levels and methods are handled by a driver circuit external to the UART. A UART is usually an individual or part of an integrated circuit (IC) used for serial communications over a computer or peripheral device serial port. One or more UART peripherals are commonly integrated in microcontroller chips. A related device, the universal synchronous and asynchronous receiver-transmitter (USART) also supports synchronous operation.

VI. WORKFLOW DESIGN

The required flow of the entire proposed system is as shown in the Fig.3. In this case the user can manage and monitor the home devices by selecting the device from Matlab-GUI and turn ON/OFF, The FPGA kit in this scenario will detect the status of the home devices to inform the user about the device condition.

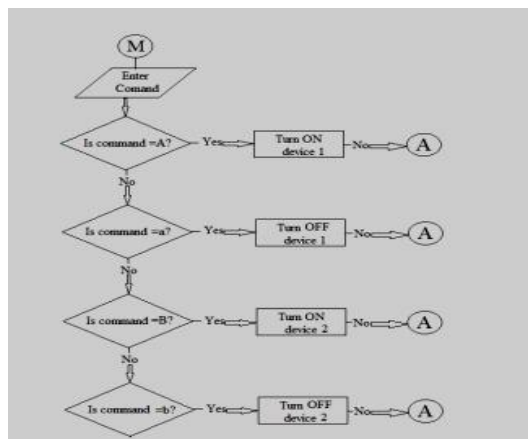


Fig.3: Required flow of the entire proposed system

VII. EXPERIMENTAL SETUP

The Fig.4 shows the experimental setup that is needed for the proposed system. The on board power supply generates 5V supply voltage required for the sensors, device driver IC and relays. The FPGA controller is connected to the analog to digital converter, GSM module, relays and the ULN device driver IC. The four control going from ADC to the controller helps for the data transfer between them. The GSM module can send and receive data to and from the FPGA. The four bit data is send to the GPIO pins by the FPGA. The FPGA also handles the device driver IC.

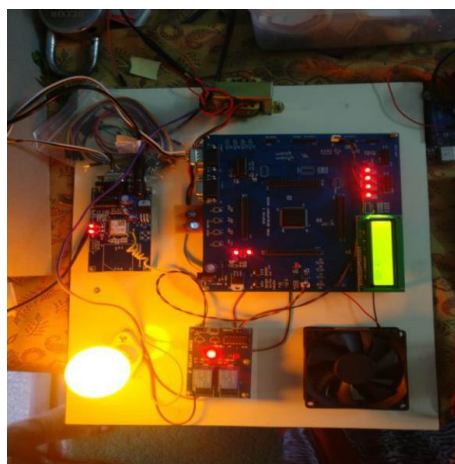


Fig.4: Experimental setup of the proposed system

V. CONCLUSION

In this paper, a design concept for smart home automation system based on the idea of the GSM technology has been obtained. The computational complexity increases as more number of loads is connected. FPGA has the inheritable parallelism function which helped

to do it sophisticatedly. The use of VHDL language in FPGA is the best alternative to do repetitive function which can be loaded onto FPGA.

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