Faculty of Media Engineering and Technology
Dept. of Computer Science and Engineering
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CSEN 605: Digital System Design
Winter 2024

Assignment and Project Document

Part 1 Homework Assignment

You are going to develop a small project based on FPGA to design a digital clock that displays the time in the format of hours, minutes and seconds.

1. Design a clock with a frequency of 50 GHZ on the DE10-lite FPGA board.

2. Assume that every clock cycle corresponds to one second.

3. Also every minute is composed of 60 seconds, and every hour is composed of 60 minutes.

4. The seconds, minutes, and hours should be of type integer when defined in your code.

5. A reset to the clock can be applied, the type of the reset is synchronous active low.

6. You are required to write both the VHDL code and a testbench to simulate the clock.

7. You must apply the reset at least once in the testbench, and in the next clock cycle, the clock should continue normally.

8. You need to test and simulate your project using ModelSim and submit a screenshot for the simulation waveform (timing diagram).

Part 2 Project Description

You are going to develop a project based on FPGA using the board provided to you (or optionally your own) and writing VHDL code.

The material in the course does not fully exploit the capabilities of the FPGA board so you must do so yourself by consulting the user manual as well as other sources. Some examples include Arduino connector with ADC, push buttons, seven-segment displays, an accelerometer, and a VGA output.

Deliver your project by presenting a demo (A 2 to 3 min video in English that clearly shows the project and how it works), in addition to a small report that outlines the idea, the set of sensors and parts you used, the implementation (codes, circuits, pin assignment) and the results. Moreover, A real model representing your application as much as possible should be implemented and presented.

Before you start your physical design of the project, use ModelSim to simulate/test your system and make sure it is working well.

You can buy many of the external devices from the local market at:

- Future Electronics (https://store.fut-electronics.com/)
    - Address: El-Sarayat Street, Abdo Basha, Abasia (in front of the Faculty of Engineering, Ain Shams University)
- RAM (http://ram-e-shop.com/)
    - Address: 32 El Falaky St., Bab El Louk, El Tahrir, Cairo, Egypt.

You'll be divided into **Two Batches**:

Batch 1: From November 11 to November 25
Evaluations for Batch 1: From November 26 to November 27
Batch 2: From November 28 to December 12
Evaluations for Batch 2: From December 14 to December 15

Submission Guidelines:

1. Submit the whole project including all the source code files.
2. A video of the simulation of your system on ModelSim.
3. A report documenting the whole project idea, inputs and outputs, pin assignment, results and brief explanation of your code.
4. Video (2-3 min) showing a demo of the project running.
5. Notepad with your names, IDs, tutorial numbers, and emails.
6. Submit a folder for the assignment solution project including all the source code files, in addition to a screenshot for the simulation waveform timing diagram.
7. Upload all the above material as a single zip file to Google Drive and make the link shareable.
8. Rename your zip folder with the following format (TEAMNUMBER_BATCHNUMBER).
9. Prepare a drive link containing the zipped folder to be submitted through a Google form before the deadline (the form will be announced later for each batch).

Things you should consider

- Availability of the components (Project description has links to some stores and their contacts)
- Group formation: exactly 6 members per team or you'll be randomly assigned.
- The contribution of each member should be clear so think of how you will divide the tasks.
- Evaluation is on campus. You need to present the project to the instructor/TA and be prepared for questions and/or modifications. All group members must be present.

NOTE THAT:

1. **NO EXTENSIONS BY ANY MEANS TO ANY BATCH UNDER ANY EXCUSE WILL BE POSSIBLE. KINDLY STICK TO THE DATES STATED ABOVE.**
2. **Sensors and actuators cannot be replaced by switch, button, buzzer, or LEDs, etc. It can only be used as additional devices; i.e., the project shouldn't be built upon a button and LED for example. It should be a REAL SENSOR such as (IR, proximity..etc) and the MOVING PARTS could be (motor, water pump..etc).**

Ideas

(You need to choose ONE of the following ideas)

A. PROJECT: "Smart Study Desk"

You are required to design a smart study desk such that it can sense the presence of the user and enhance the light intensity of the room if needed. Once the user approaches the desk he/she shall be able to grab what he/she needs from the drawer of the desk. Finally, the desk should record and display how much time the user used the desk.

Tasks:

1) The system needs to sense if a person approaches it.
2) If a person approaches the desk, the light intensity of the room shall be checked.
3) If the light intensity of the room is low, the lamp shall be turned on.
4) Unconditionally, if someone approaches the desk, the drawer shall open for 10 seconds and close afterward.
5) The time sat by the person on the desk shall be displayed after he leaves on the 7 SEGMENT DISPLAY (in seconds).

B. PROJECT: “Smart Parking System”

A special place has a special type of garage, a man is responsible for opening a gate whenever he sees a car, once the car enters after the gate opens, the monitor should increase the number of entering cars by 1.

Tasks:

1) Initially, the number of cars is zero.

2) You can use a button to simulate the man who opens the gate.

3) You have to use a sensor to detect that the car has passed the gate.

4) Upon detection of the car passing the gate, the gate should return to its initial position using an actuator of your own choice.

5) The number of cars shall be displayed on the 7 SEGMENT DISPLAY.

C. PROJECT: “ Walking Stick”

You are required to design a walking stick for visually impaired people. The stick gets activated and deactivated by the user. It alerts the user whenever an obstacle is ahead by vibrating using the obstacle avoidance sensor. It also has another feature; when the stick falls from his/her hand, it keeps beeping until found.

Tasks:

1) The user activates and deactivates the stick through a switch/button (in FPGA/external button..etc).
2) Using your own choice for the obstacle avoidance sensor, whenever an obstacle is detected the stick should vibrate using a moving part of your choice.
3) Using a touch sensor or equivalent, the stick detects whether it is dropped or not and if it is dropped a warning sound should be produced using your own choice of sound device.

D. PROJECT: “Mini Car”

You are required to design a car that uses buttons/switches to move forward, backward, right, and left. It has a lane sensor and whenever it goes out of the lane a warning message should be displayed on the screen. "ALERT"

Tasks:

1) The car should be controlled to move in all directions

2) The system should detect if the car gets out of the lane using a sensor of your own choice

3) Whenever the system detects an out-of-lane state there should be an Alert displayed on the screen warning the user (if the car gets back in the lane the alert should be removed).

E. PROJECT: “Plant care system”

You are required to implement an automated plant care system with 2 stages:
1. Stage 1 is for watering the plant.
2. Stage 2 for dispensing plant fertilizers.

Tasks:

1) The user needs to start the system using a button or any equivalent.
2) The system should pump the water using a water pump for a specific amount of time from your choice and then the water pump stops after that time and this is marked as stage 1. Moreover, you should switch on an LED to determine that you are in stage 1.
3) The system should dispense the plant fertilizers using a motor after stage 1 is finished automatically. This should be indicated using another LED than that used in Stage 1.
4) You should have a stop button to stop the system.

F. PROJECT: “Pet Companion”

You are required to design a toy car that plays a "catch me if you can" game with your pet. The car moves away whenever something (possibly a pet) gets near to it. The car also has lights that turn on whenever it's dark so that your pet can keep playing all the time.

Tasks:

1) When the pet approaches the car, it should be detected using a sensor of your own choice.
2) Whenever the pet is detected the car should move (Motor on) away from the direction of detecting the motion.
3) The car should detect the environment’s light intensity to dynamically turn on and off the LEDs.

G. PROJECT “Smart Packaging System”

A factory that produces magnetic products uses a smart packaging system where the conveyor belt carrying the products keeps moving until a certain amount of products are delivered (5 products). Then, it stops and alerts the workers to firm the container of the products. Once the worker is done, he/she puts the belt back on.

Tasks:

1) You need to be able to count the number of magnetic products.
2) The number of products is displayed on the 7 segments.
3) Once the number of products reaches the maximum number (5 magnetic products), the belt needs to stop.
4) Then, you need to check if any of the workers are nearby.
5) If no one is near the belt you need to alert the workers to close the package.
6) A switch is then used by the worker to turn the system back on and reset the count of products.

H. PROJECT “Gas leak detection system”

You are required to design a detection system for a smart factory that detects gas leakage.

Tasks:

1) The system should detect the presence of gas.
2) In case of gas leakage, an alert siren should go off along with a visual alert (Alert message on screen).
3) In case of gas leakage, the system should detect if there are workers present. In case of workers presence within the factory range, The system should open the factory doors.

“BONUS”

- If you added an extra feature using an ANALOG SENSOR that requires an extra microcontroller connection (for example: Arduino Board) (or FPGA-based ADC module/code), it will be counted as a bonus to any of the ideas listed above. You must use the microcontroller for ONLY reading the sensor values; however, any output must be controlled through the FPGA.

Good Luck :)