Electronic Engineering

Advanced Embedded System Lab

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Prof. Dr. Hayek Ali

Documentation for Vending Machine

Team F

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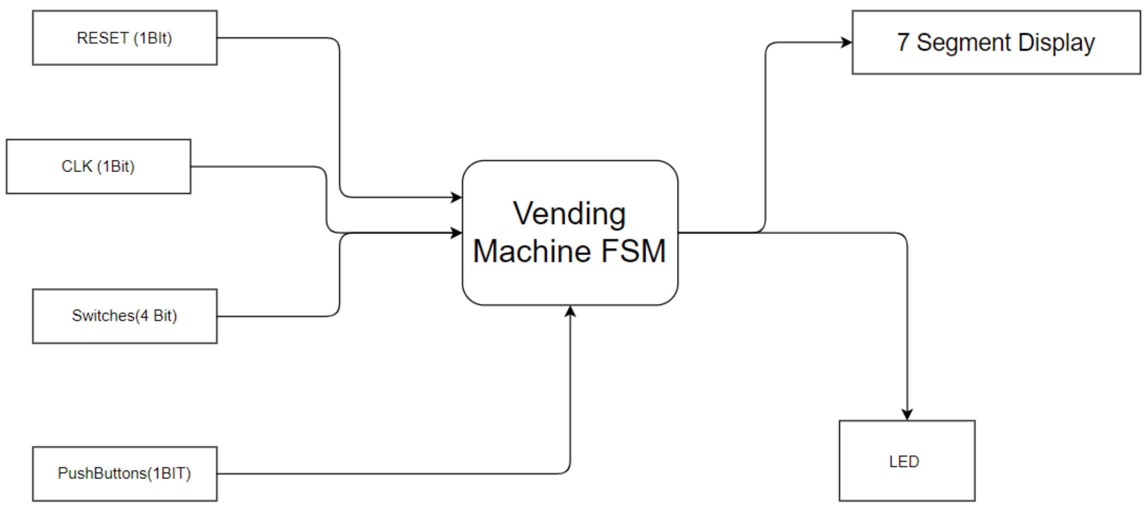
I. INTRODUCTION

A typical Vending machine which is programmed with advanced hardware using an FPGA development board. It will be designed in such way where every aspect is processed with high accuracy by creating a VHDL code which will then be implemented in a FPGA board. This machine gives the user the option of having various goods on the go and pay accordingly. The specialty of this machine is designed in its code where an FPGA development will play a
crucial role as this whole system will be based on the board inputs and outputs in real time.

II. CONCEPT DESCRIPTION

Block Diagram:



Project Description:

Our Vending machine is programmed with advanced hardware using an FPGA development board. It will be designed in such a way where every aspect is processed with high accuracy by creating a VHDL code which will then be implemented in a FPGA board. This machine gives the user the option of having various goods on the go by proving secure payment method. The specialty of this machine is designed in its code where an FPGA development will play a crucial role as this whole system will be based on the board inputs and outputs in real time.

Hardware and Software Used:

- Nexys A7 100T FPGA board
- Xilnix Vivado Software
- ModelSim for Vhdl
- UML diagrams
- KICAD

III. PROJECT AND TEAM MANAGEMENT

A. *Used Methodology and Task Breakdown*

In our vending machine project implemented on an FPGA, we employed the following project methods to ensure effective management and coordination:

Agile Methodology: We adopted an agile approach to project management, specifically Scrum. This methodology allowed us to break down the project into smaller, manageable tasks and work on them in short iterations called sprints. We held regular sprint planning meetings, daily stand-up meetings, and sprint review meetings to track progress, discuss any challenges, and
adapt the project plan as needed.

Breakdown: To manage our tasks efficiently, we followed the following breakdown;

***Requirements Gathering*:** We started by clearly defining the functional and non-functional requirements of the vending machine. This step involved understanding the desired features, user interactions, and system constraints.

***VHDL Modelling*:** One part of our project involved VHDL modelling. We divided the VHDL modelling tasks into logical modules, such as the vending machine controller, 7-segment display interface, switch and button inputs, and price calculation. Each team member was assigned specific modules to work on based on their expertise.

***FPGA Implementation*:** Another major part of our project was implementing the VHDL code on the FPGA. We allocated tasks for FPGA implementation, including synthesis, implementation and bitstream generation. Team members responsible for this stage worked closely with the VHDL modellers to ensure seamless integration and functionality.

PCB Design: The final part of our project involved designing the printed circuit board (PCB) for the vending machine. This task required layout design, component placement, and signal routing. Team members with experience in PCB design were assigned these responsibilities.

B. *Team Management:*

VHDL Modelers: The VHDL modelers were responsible for designing and implementing the various VHDL modules required for the vending machine. They worked on tasks such as creating the controller logic, interfacing with the 7-segment display, and handling switch and button inputs.

FPGA Implementation Specialist: This team member had expertise in FPGA implementation and was responsible for synthesizing the VHDL code, performing placement and routing, and configuring the FPGA with the generated bitstream. They ensured that the VHDL code was correctly translated and executed on the FPGA hardware.

PCB Designer: The PCB designer was responsible for designing the PCB layout, including component placement, signal
routing, and ensuring the manufacturability and functionality of the board. They collaborated with the VHDL modellers and FPGA implementation specialist to integrate the FPGA and other components onto the PCB.

Specific Assigned Task

Shihab Ud Doula: VHDL Code And TestBench Simulation,
Neaz Mahmud: FPGA (Dropped The course)- incomplete.
Yunsuk Choi: PCB Design (Dropped the course)-incomplete

IV. VHDL & FPGA IMPLEMENTATION

VHDL

In the provided VHDL code, a vending machine is implemented with the following functionality:

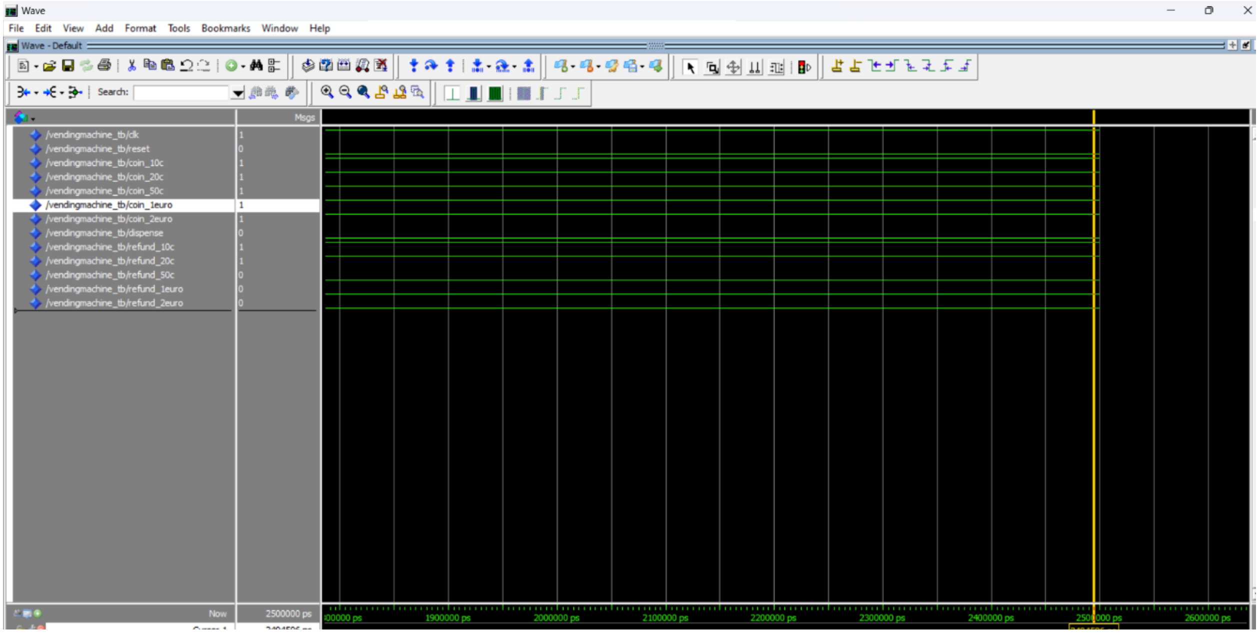
- The vending machine has five inputs: clk (clock signal), reset (reset signal), coin_10c (10-cent coin input), coin_20c (20-cent coin input), coin_50c (50-cent coin input), coin_1euro (1-euro coin input), and coin_2euro (2-euro coin input).
- It has five outputs: dispense (dispense signal indicating whether a product should be dispensed), refund_10c (10-cent refund signal), refund_20c (20-cent refund signal), refund_50c (50-cent refund signal), refund_1euro (1-euro refund signal), and refund_2euro (2-euro refund signal).
- The prices of three products (tea, coffee, and bread) are defined using unsigned signals (price_tea, price_coffee, and price_bread).
- Inside the process, the vending machine accumulates the number of each coin inserted based on the rising edge of the clock signal.
- The total amount of money inserted is calculated by multiplying the number of coins with their respective values and summing them up.
- The process checks if the total amount matches any of the product prices. If a match is found, the dispense signal is set to '1', indicating that a product should be dispensed, and the refund signals are set to '0'.
- If the total amount exceeds the product price, the refund amount is calculated by subtracting the product price from the total amount. The refund amount is then used to determine the number of coins to be refunded in each denomination.
- If the total amount is less than any product price or no product is selected, the dispense signal and all refund signals are set to '0'.

The provided testbench simulates different scenarios by manipulating the input signals of the vending machine. Each scenario represents a different combination of coin inputs and verifies the behavior of the vending machine with respect to product dispensing and refunding.

Note: The full code and other necessary files are uploaded on GITHUB:

https://github.com/Shihab-007/Advanced-Embedded-System-Hardware-Enginnering/tree/main

Testbench Code Simulation:



FPGA:

Incomplete

V. PCB DESIGN (Incomplete)

To design the PCB for our FPGA evaluation board, the following steps are taken.

1. We selected the FPGA which was Artix-7.

2. Then we identified the necessary modules to be included in the PCB design. Those are FPGA Artix 7, power supply, JTAG programming interface, clock (CLK) interface, and reset interface. 7-segment displays, and 7 switches.

3. For the next step, we planned the board layout. In this step, we had to consider the size and form factor of our PCB. We determined the placement and orientation of each module on the board, ensuring that there is enough space for traces, power supplies, etc.

4. After this stage, we created the schematic: We drew our schematics using KiCAD tool. The layout of the schematic comprises of three layers. Those are (1) Power Supply Schematics, (2) FPGA Utilities Schematics, and (3) FPGA Externals Schematics. Power Supply schematics ensure that power supply and ground connections are properly distributed throughout the design. FPGA Utilities Schematics include Artix-7 chip, JTAG programmer interface, Reset module, and Clock module. FPGA Externals Schematics include 7-segment display and 7

switches.

5. Then we moved on to designing the PCB layout. This step required us to place each component on the board according to our planned layout. In this step, we focused on criteria such as minimizing trace lengths and avoiding any interference between signals.

References

1. *Alaattinyilmaz. (n.d.). vending-machine/vending_machine.v at master · alaattinyilmaz/vending-machine. GitHub. https://github.com/alaattinyilmaz/vending-machine/blob/master/vending_machine.v*

2. *comp.arch.fpga | Simulation of VHDL code for a vending machine. (n.d.). https://www.fpgarelated.com/showthread/comp.arch.fpga/89364-1.php*

3. *Falcao, R. E. (2022, April 23). Vending Machine in Verilog HDL | Medium. Medium. https://medium.com/@rebsfalcao15/design-of-vending-machine-using-verilog-hdl-42cede6cf8bb*

4. *Nation Innovation. (2019, April 13). Vending Machine| VHDL Code | Simulation | FSM Based | Nation Innovation | B.Tech Final Year Project [Video]. YouTube. https://www.youtube.com/watch?v=ywrSG9J3taE*

5. *Zhang, J. (2012). The Design, Simulation, Verification and Implementation of Vending Machine Based on FPGA. https://kb.osu.edu/dspace/handle/1811/52066*