



Faculty: <b>SCHOOL OF ELECTRICAL ENGINEERING</b>	
Subject : <b>ELECTRICAL ENGINEERING LABORATORY</b>	Review : Release Date : 5 March 2015 Last Amendment : 27 March 2022 Procedure Number :
Subject Code : <b>SKEL 3742</b>	



**SEKOLAH KEJURUTERAAN ELEKTRIK  
UNIVERSITI TEKNOLOGI MALAYSIA  
KAMPUS SKUDAI  
JOHOR**

**SKEL 3742  
VLSI SYSTEM DESIGN LAB**

**Lab Project 1: Vending Machine System**

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## Project Introduction

A vending machine is a machine which dispenses items after the customer inserts currency or credit into the machine and it is the basis of many software and hardware projects. The basic structure of the vending system consists of two unit modules; datapath and control unit. **Datapath unit is the main body of the system which does the main tasks of system such as storing and manipulating data. Control unit operates to control the process inside the datapath unit such as what to do next.**

The objectives of this project are:

1. To design the vending machine system using combinational and sequential logic design based on project specifications.
2. To draw the combinational and sequential logic circuit of the vending machine system using schematic design entry/hardware design language (HDL) coding and verify its function using Altera Quartus II Tools software.
3. To prototype and demonstrate the design of the system using Altera FPGA DE2 board.

Your system should be able to accumulate coins inserted and compare with stored element (the price of the items). Comparators to indicate the controller to decide the next step to take: continue counting or release the items.

## Project Task

In this project, you are required to design a vending machine that accepts coins and provides products. The vending machine can accept 10¢, 20¢, and 50¢ coins. There are three types of products available, Product A, Product B and Product C with certain prices. Design a vending machine system using Quartus II schematic entry/HDL coding. Write a report with the well-presented design steps, simulation results and FPGA prototyping methodology are expected to be produced at the end of the project after the third session of the lab.

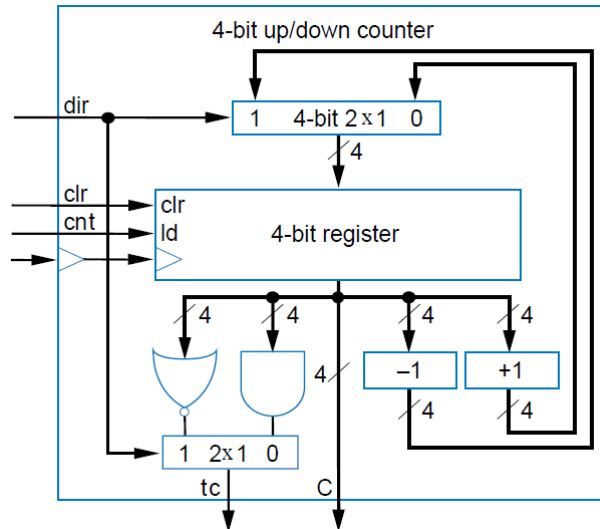
### Some design guidelines:

1. Determine the number of bits to represent the coins being inserted to the machine.
2. Determine the number of bits to represent selection between Product A, B and C.
3. Display total count of inserted coins as output.
4. Before the product selected can be dispensed, BUY button must be pressed.
5. Determine the required states for the state diagram.
6. Determine the required inputs, outputs and internal signals.
7. Design a circuit for the vending machine using multiplexers, counters, adders and similar logic blocks.
8. Use registers or flip-flops to enable storage of addition operation.
9. The control signals will be eventually connected to the toggle switches on the DE2 board.
10. The outputs from the vending machine will be eventually displayed on the 7-segment displays on the DE2 board.
11. For your design, use appropriate gates, components and mega functions from the Quartus II system library.

Identify input and output of your system, encoding method, circuit topology and suitable algorithm to be used. Design the system using combinational and sequential logic gates and verify the design using Quartus II CAD Tool. Final task is to prototype and demonstrate your system using FPGA DE2 board. Refer to Quartus II and FPGA tutorial to help you to implement this project.

### Week 1:

Design the vending machine system including a block diagram for the datapath and a state machine diagram for the control unit. Below is a sample datapath unit for your reference. Use this as an example to design your datapath.



**Figure 1:** Up/Down Counter (F. Vahid, Chapter 4, Digital Design, 2006)

### Week 2:

Design the datapath and control unit using schematic entry or Verilog HDL. Verify your design by using simulation waveform to check design correctness.

### Week 3:

Implement the completed vending machine on the Altera DE2 FPGA board. Use the toggle switches for input and 7-segment display as well as LEDs for output.