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DEPARTAMENTUL CALCULATOARE

13-floor Elevator

DSD PROJECT

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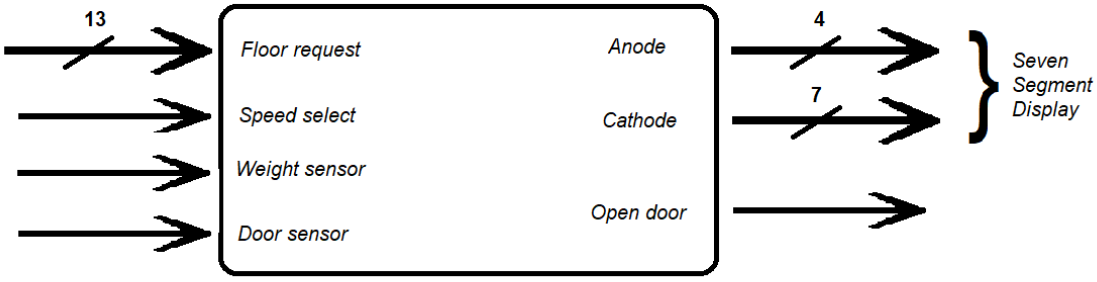
1.Specification

Implement an automaton that comands the elevator of a hotel with 12 floors and a ground floor(P). The automaton has only one set of floor command inputs, since requests from both inside and outside the elevator are processed in the same way. The order of fulfillment of the floor requests considers the direction of the elevator, going to the floors in its path first and then turning the opposite way. The elevator also has a weight sensor input that doesn't allow it to start if a maximum weight is exceded. The elevator also doesn't move until the doors close and another sensor checks if something stops their closing. The speed can be swtitched between 1 and 3 floors / second.

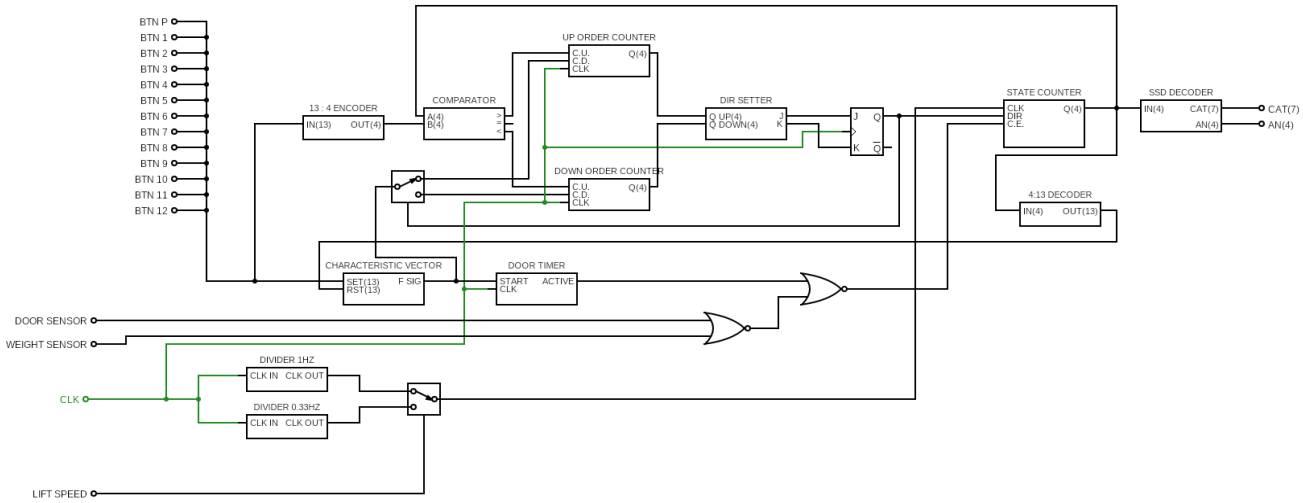
The elevator is initially at the ground floor with its doors open.

2.Design

2.1 Black box



2.2Detail diagram



3.Structure and functionality

3.1 Resources

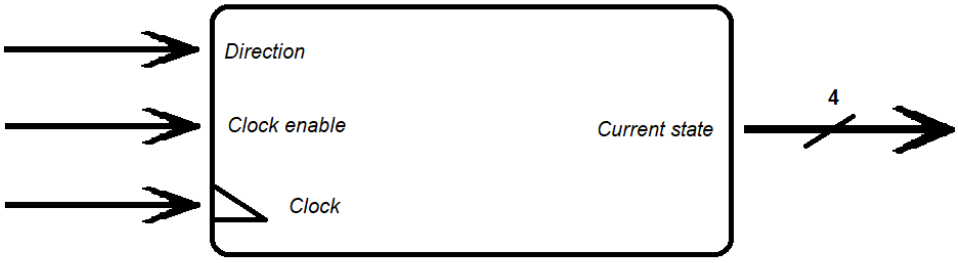
- Edge detector

For a more intuitive user interface we have used the switches as inputs. One edge detector is connected to each switch and sends a signal when the switch switches state (simulating the press of a button).

- Two clock dividers: to 1Hz and 0.33Hz

They correspond to the desired speeds of the elevator of either 1 or 3 seconds per floor. Through a multiplexer that selects between them, the chosen divided frequency goes into the main counter.

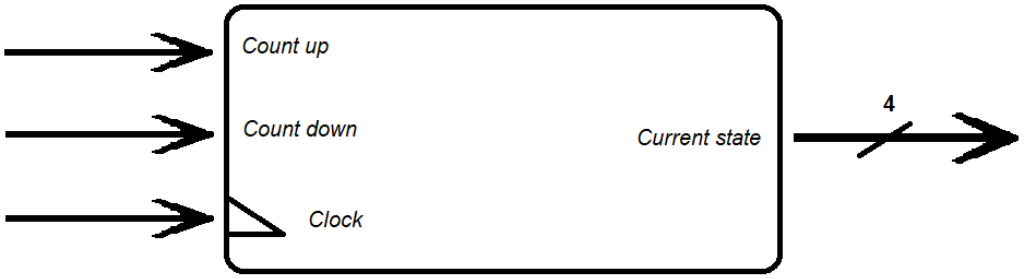
- Synchronous reversible modulo 13 counter



A simple reversible modulo 13 counter with clock enable feature. One such counter is used to determine the current position of the elevator, its clock enable input being active only when the elevator is moving. The clock signal comes from a multiplexer that selects between the possible movement speeds of 1 or 0.33 Hz.

Such counters are also used in building more complex asyncronous counters.

- Asyncronous counter



Although having a synchronous counter as its main component, it simulates the functionality of an asynchronous one. When detecting a rising edge on either the count up or count down inputs it increments or decrements its value. The clock used is the one of the main circuit.

Two such counters are used in the automaton: One for counting the floor commands the elevator has to fulfil above it and one for the requests below.

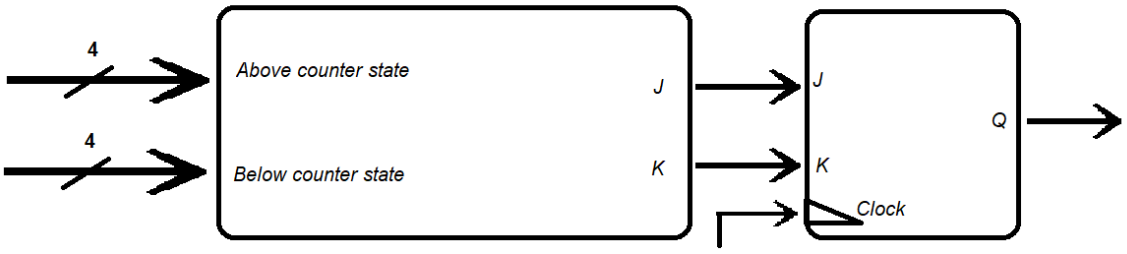
- 13:4 encoder

The encoder is wired to the buttons for each floor and converts the request into a binary number (4 bit signal) that can be later compared.

- 4-bit comparator

This component compares the requested floor to the current floor of the elevator. If greater, a signal is sent further to the asynchronous counter for the requests above and if less, a signal is sent to the one for requests below.

- Direction setter + JK flip-flop



This component decides the current direction of the elevator (of the main counter). It has as inputs the states of the two asynchronous counters. The flip-flop memorizes this direction. When one reahes 0 (all the requests in that direction have bin fulfilled), if there are still requests in the other direction a signal is sent to set or reset the flip-flop.

- "Characteristic vector"

This component is composed of 13 JK flip-flops that memorize if the elevator has to go to each floor or not. The SET input is connected to the request buttons of the elevator, while the RESET input is connected to the decoded signal of the main counter (the current floor of the elevator). When the elevator reaches a floor that it was requested to, the FULFILLED output becomes active, further starting the door open timer and decrementing the asynchronous counter corresponding to its direction.

- 4:13 decoder

This decoder is used to decode the current state of the elevator (from the main counter) in order to be easier processed by the characteristic vector component.

- Door open timer

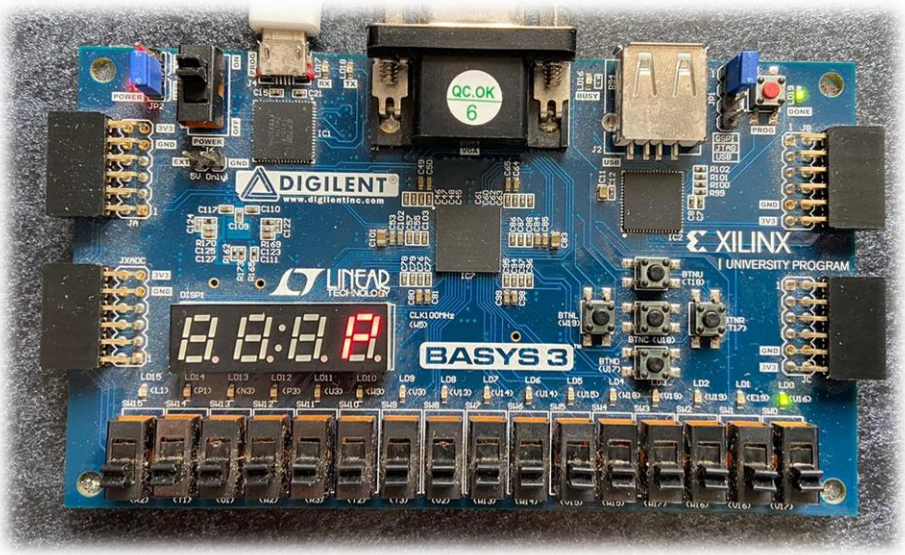
When receiving a signal from the characteristic vector that a request has been fulfilled, it starts counting for 5 seconds, having as clock input the one divided to 1 Hz. Its output goes further as a condition for the clock enable of the main counter (not allowing the elevator to move), and opening the doors (signaled by the open door led).

4.Utility and results

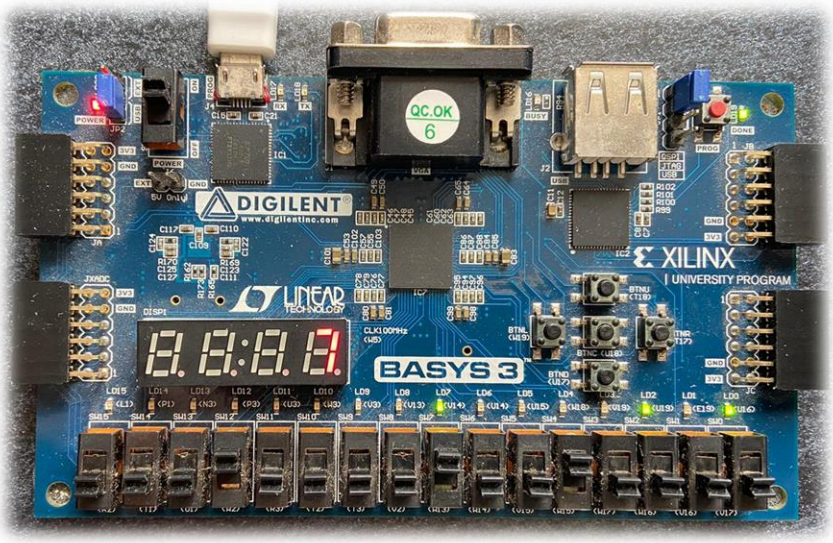
We have used a Basys 3 FPGA board for development and testing, but the design could be easily modified to fit other boards with enough inputs.

The only outputs are a led (led 0) that signals the open door and the seven segment display that signals the current floor of the elevator. As inputs we have used only switches, flipping any of the first 13 ones requests the elevator to its corresponding floor. Furthermore, switches 13 and 14 represent the weight sensor and the door closing sensor, any of which being active stopping the elevator from moving, and switch 15 being the toggle for the speed of the elevator.

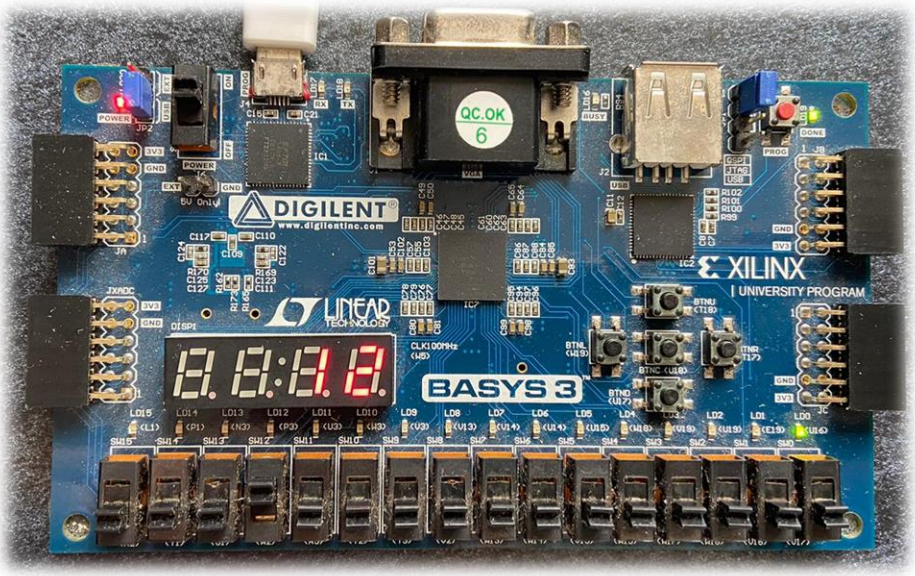
* For debugging and easier tracing purposes, we have added a few other outputs. We have wired led 2 to show when the elevator still has requests to fulfil and leds 7 to 10 and leds 12 to 15 to display in binary the number of floors it has to go to below and and above it respectively (the states of the two asyncronous counters). These outputs can be easily removed if necessary.



At the beginnig, the elevator waits at the ground floor with its doors open. Now just flip the switches corresponding to the floors you want the elevator to go to. You can watch it prioritizing the requests in its direction of movement.



This picture shows the elevator stopped at floor 7 before going further to floor 12.



Here the elevator is shown at floor 12 without any further requests, waiting to close its door after 5 seconds.

5.Further development

A more efficient way of requesting the elevator at each floor would be by having two different buttons, one for wanting to go up and one for going down. Although possible to implement, we have chosen a simpler approach because some people don't know how those buttons realy work (i.e. thinking the up arrow would mean to tell the elevator to come from below) and that could complicate the user experience.

Also, we belive this automaton is ready to be implemented in a real elevator, wiring the clock enable of the main counter to something that gives power to the motors and using the direction setter signal to tell the motors which way to turn. Another modification would be, in that case, turning the current floor output from one for a display with 4 digits to one for a display with only 2 digits.

6.Technical justifications for the design

We found this design to be the easiest and most intuitive to implement. We have a relative small number of custom components that work well not because of their individual complexity, but because of the way they are linked together.

This design simulates a natural thought process, simply using information about how many requests there are above and below the current position of the elevator and what floors the elevator has to stop to precisely.