

FPGA Lab Mini-Project Report

Railway Handcar Simulator

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Introduction and Motivation:

The Railway Handcar consists of a 4-wheel cart, with a see-saw system on top operated by 2 people. When one end is pulled down, and the other end is pulled up, the cart moves. By moving the see-saw in the other direction, the direction of movement can be reversed.

Railway handcars were used in the 1800's and 1900's for railroad inspection and maintenance. These days however, they have been replaced by motorised versions which do not require manual labour to move.

The motivation behind this project was to fully utilise the various input and output pins on the FPGA board through a fun and educational handcar simulator. Both automatic and manual movement capabilities have been implemented for greater control over its movement.



Fig 1. Railway Handcar in operation

Implementation:

Based on the principle of the railway handcar, a modified version was designed and implemented in Verilog. There are 5 user inputs to control the movement of the railway handcar, which is displayed using 2 LEDs on the FPGA kit's LED array. These 5 inputs are RIGHT, LEFT, RESET, AUTO and DIR. The position of the handcar is given by the output POS, which is an 8-bit register, corresponding to the 8 LEDs on the board.

RIGHT and LEFT are push button inputs which emulate the see-saw motion of the handcar, with the direction of movement given by a DIP switch input DIR. When DIR is 0, the handcar can only move right, and when DIR is 1 the handcar can only move left. To move the handcar, RIGHT must be pressed first, followed by LEFT (if DIR is 0) or vice versa if DIR is 1. After a successful input sequence, the handcar moves in the desired direction by one LED.

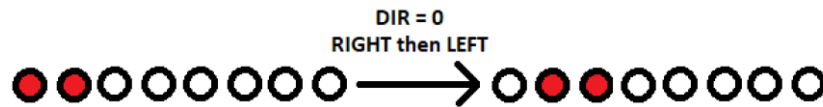


Fig 2. Movement of the handcar on the FPGA board

The handcar will not move if one input is pressed multiple times and then the other input is pressed. For example, if we wanted to move to the right, we have to press RIGHT once, followed by LEFT. If we were to press RIGHT twice and then LEFT, the handcar will not move. Only a successful combination of one RIGHT and one LEFT (or vice versa) will result in movement. The FSM diagram is given in Fig 3.

Note: these push button inputs are passed through a debouncer module before being given to the main FSM module.

RESET is an asynchronous push button input which resets the position of the handcar to the default position – the left end of the LED array. Note: if the handcar reaches one of the ends of the LED array, it will be stuck unless the direction of movement is changed.

The final input is AUTO, which is a DIP switch input. By default, it is set to 0 which signifies manual movement of the handcar, i.e., using the see-saw mechanism. If AUTO is set to 1, the handcar moves automatically in the direction given by DIR, without the need for RIGHT and LEFT inputs. The speed of the car's movement is decided by a separate clock module specific to the automatic mode. A clock decider module is used to check and select the appropriate clock based on whether the handcar is in manual or automatic mode. Both the DIP switch inputs can be modified on the fly for maximum control of the handcar.

State Diagram:

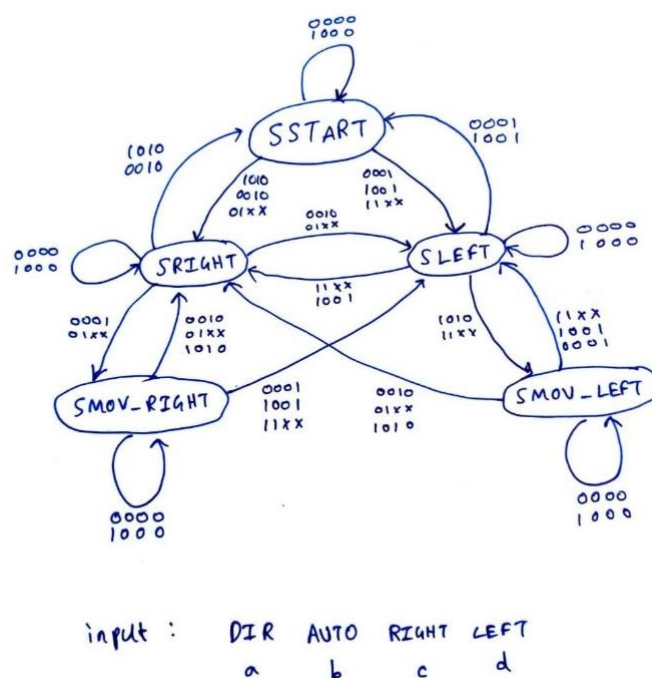
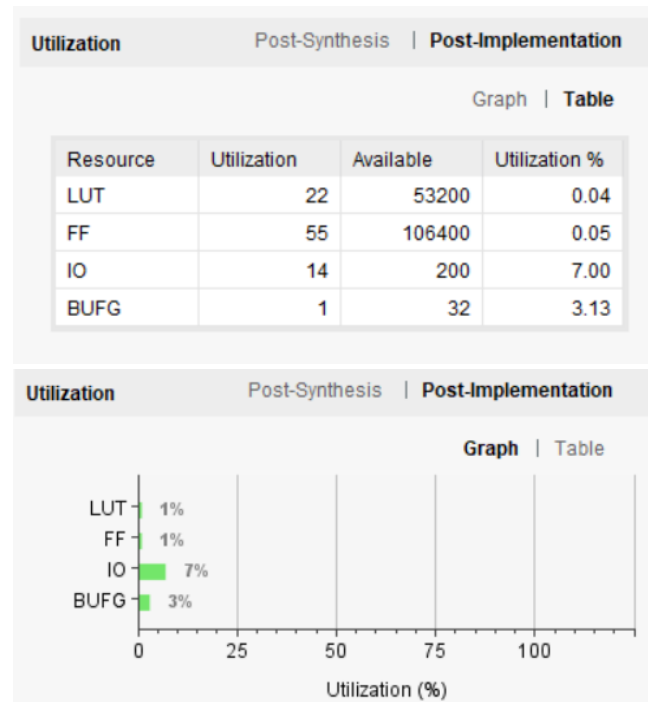


Fig 3. Moore Model of the Railway Handcar

Hardware Utilisation:



Conclusion & Future Scope:

A Railway handcar simulator was designed and implemented in Verilog, and displayed on the FPGA board. The handcar's motion could be made more realistic by adding momentum to its movement, i.e., the handcar will continue to move in the given direction for some time depending on the number of see-saw motions used previously before stopping. The handcar itself can be displayed using VGA, for more visual clarity and aesthetics.