FPGA Implementation of a Car Washing System usingVerilog HDL

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***Abstract*— This article introduces a car washing system with five working modes based on the washing quality. Depending on the washing quality, these modes used in a variety of circumstances. The car washing system is created using the Xilinx Vivado 2022.1 Suite software and the implementation is done on Nexys 4 DDR board, which is based on the hardware description language Verilog HDL. After implementation, the simulation results of the different modes of operations are obtained and verified. These results are shown and discussed in this paper.**

Keywords—car washing system, Nexys 4 DDR, Verilog HDL

I. Introduction

One of the most notable advancements is the automation of processes and technologies. This is a collection of techniques and equipment made to be used in systems that enable the management of technological operations without the direct involvement of people. Automated car washing is one such method that has recently gained a lot of popularity with the general population. There are two types of automobile washing systems: manual and automatic which can be contact or contactless. Modern technological innovations in the car washing industry can be divided into distinct categories, such as new washing techniques (touch-free and hybrid washing technology), sophisticated water recycling systems (based on biological water treatment), water desalination and purification techniques (by reverse osmosis), and other environmentally friendly and cost-effective innovations.

The following are the primary benefits of automatic car washing [7, 8]:

- No mechanical impact that might scratch the paint;
- Quick washing procedure;
- Thorough cleaning of areas that are difficult to reach, such as the grille and wheels;
- Personalization;
- System that is simple to use.

The system's primary drawbacks are mostly due to the high development costs.

The field programmable gate array and programmable logic devices using Verilog HDL or VHDL are appropriate options for realising the system. The interactions between the components of these programmable devices are not specifically defined throughout the manufacturing process. This entails the capability to create several devices using a certain FPGA and to alter their configuration and, consequently, the mode of action, both during the development process and even while they are in use. Utilizing PLDs and FPGAs has a number of benefits, including the ability to launch new washing programmes fast, improve quality, and increase client demand.

In this research, a design for a car washing system based on a control flow diagram using FPGA and the Verilog HDL language in the Vivado Design Suite of Xilinx software is proposed. This kind of automobile washing system offers the flexibility to operate in six major modes in various states: water cleaning, foam spraying, adding wax, drying, under carriage cleaning, wheel cleaning and clean coat shield spraying. The Verilog Test Fixture simulation results for the various configurations shows that the design system is functioning.

II. Control Flow Chart

The car washing system has five different operating modes: "Lunar wash", "VIP," "Extra foam," "Standard," and "Low cost."

Before starting a new set regime, the previous one must be stopped.

The "Ready" block looks for things like alarms, human input, foam, wax, and other things.

The states that must be triggered for each of the different modes are "Foam," "Water", “Undercarriage Wash”, "Wax," "Dry," “Wheel Wash”, “Clean Coat Shield “and "Finish."

When the car is in the "Foaming" condition, the car wash system sprays foam through nozzles positioned all around the vehicle to achieve total coverage.

In “Washing” state, all other conditions are stopped and clean water is supplied to the nozzles.

In “Wheel Wash”, water is sprinkled on the wheels through nozzles.

In “Undercarriage Wash”, water is sprinkled on the undercarriage of the car from the nozzles attached on the wash blower floor.

In “Waxing” condition, wax is applied to the nozzles and the vehicle is sprayed.

In “Drying” state, the system activates the blow valves for a short period of time until the vehicle is dry.

In “clean coat shield” state, a ceramic coating is sprayed on the car.

A control flow chart for a car washing system with five working regimes in various states is shown in Figure 1. A brief period of time is set to switch the system back to the initial state when the procedure of "Finishing" for each mode is complete.

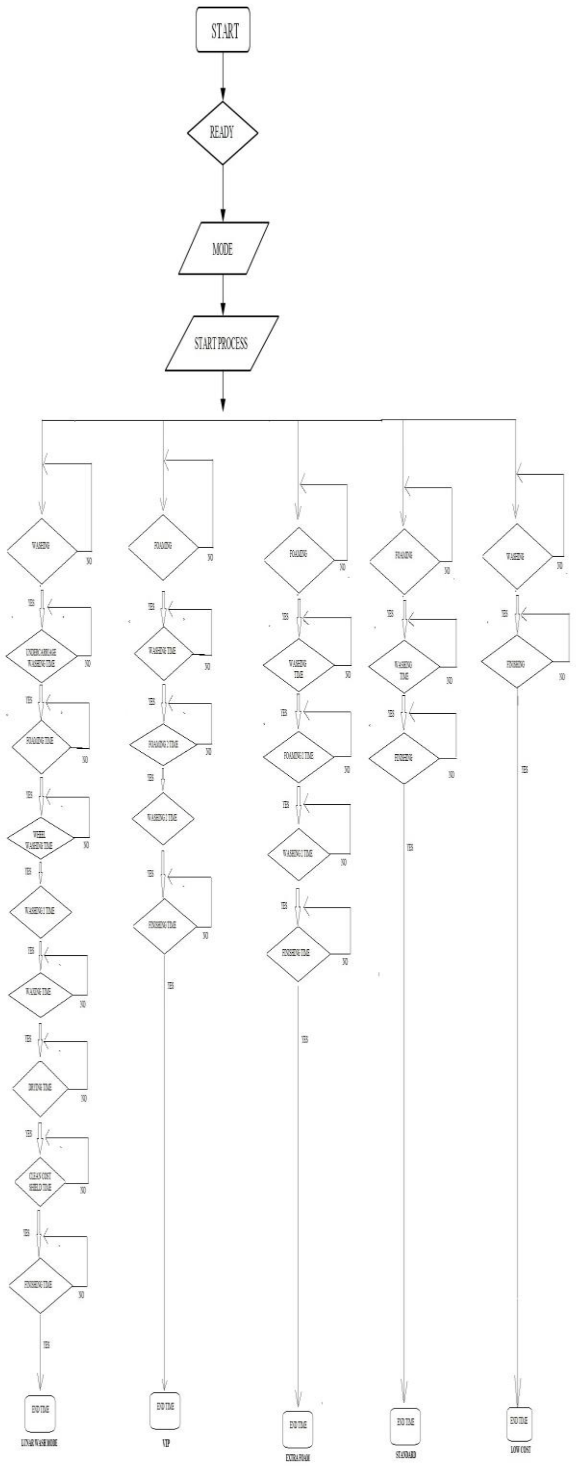

Fig. 1. Flow Chart

III. DESIGN IMPLEMENTATION

The design programme is synthesised and implemented in the Xilinx Vivado 2022.1 Suite software through Verilog HDL on the basis of the provided control flow chart (Figure 1).The Nexys 4 DDR board development kit was chosen for the design. The input signals that are used are "clk" for a general timer for all operations, "btn start" for a start button (on/off), "rst" for a reset; “lunar wash mode”,"vip mode," "extra foam mode," "standard mode," and "low cost mode" for choosing various washing modes and "t1" to"t8" for timers for various operations. The outputs "foam," "foam2," "water," "water2," "wax," "dry", “undercarriage washing”, “wax2”, “clean coat shield”, “wheel wash” and "finish" are used to initiate the various processes of the system.

The registers used are “cst” for the current state and “nst” next state.

IV. SIMULATION RESULT

The simulation results of the car washing system under various operating conditions are shown in the following figures. The red states in the simulations that are being displayed are undiscovered values (start button not pushed). The moment the button is pressed, the program switches into the selected mode and begins to operate. The fixed times in each mode are chosen as an example and are modifiable as needed.

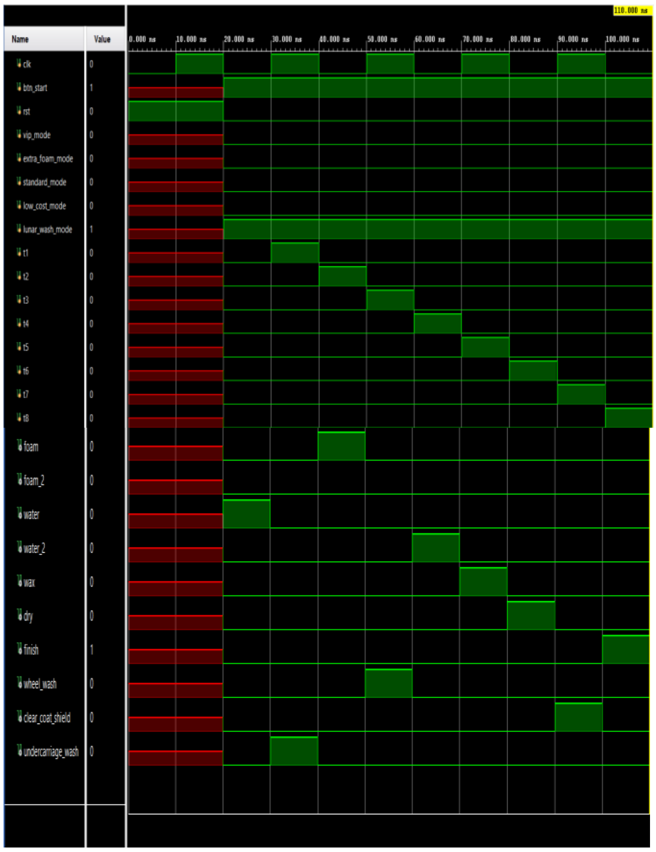

Fig. 2. Lunar Wash Mod

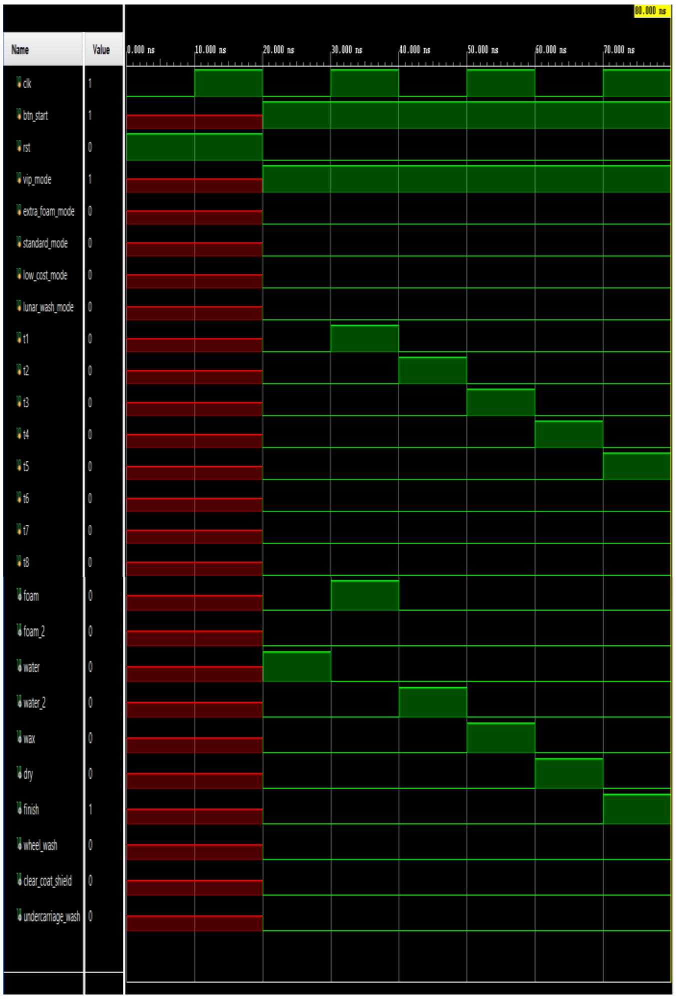

Fig. 3. VIP Mode

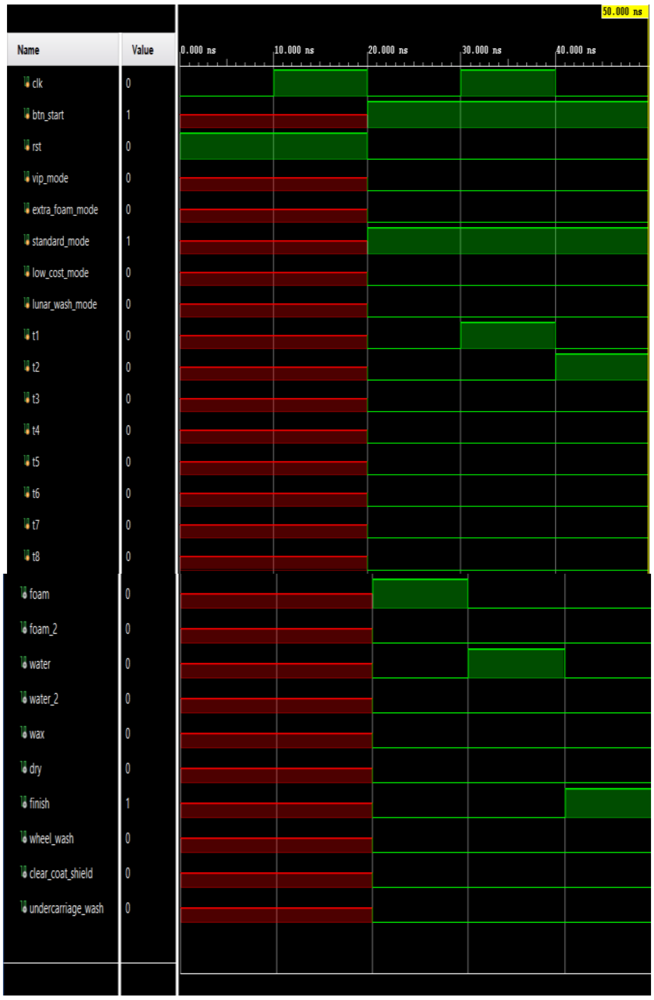

Fig. 4. Standard Wash Mode

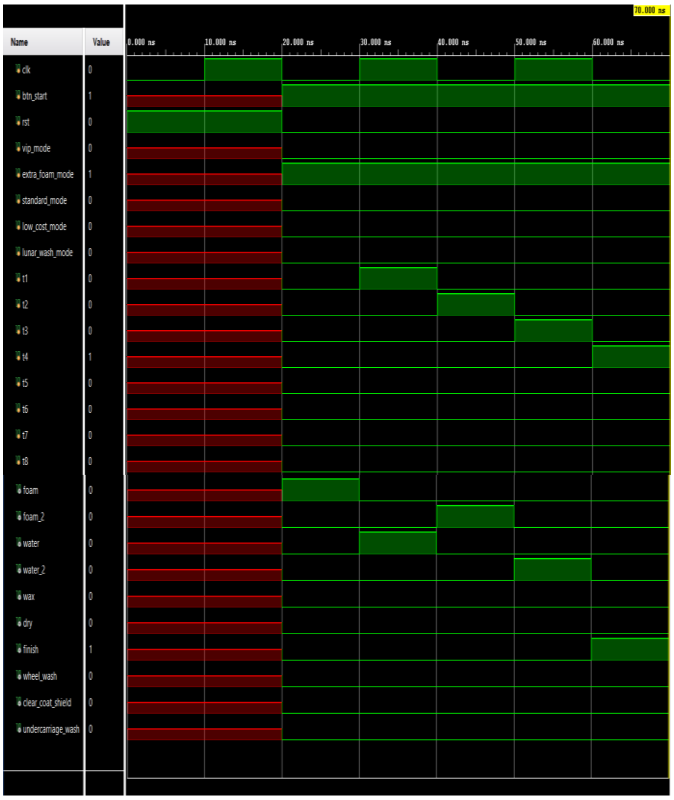

Fig. 3. Extra Foam Mode

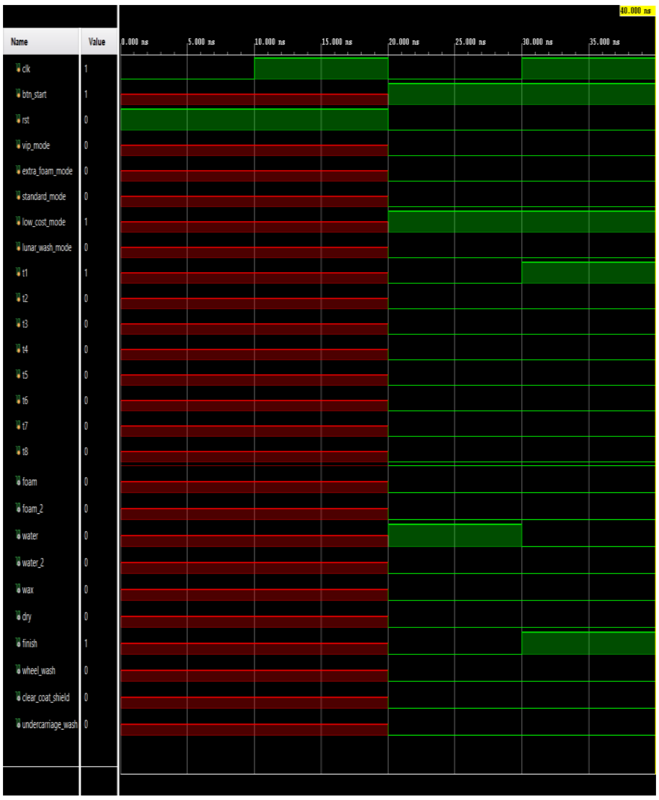

Fig. 5. Low Cast Mode

V. CONCLUSION

The use of automated car washing systems will increase in the future as they include a number of benefits such as time and money savings, an intuitive method, profitability, a quick washing process, meticulous cleaning of difficult-to-reach areas like the grille, wheels, and others, etc. In the present world, field programmable gate arrays and complicated programmable logic devices are commonly employed. They are a cutting-edge and fruitful approach to designing numerous electromechanical things and systems. The control program has been created in the Vivado 2022.1 software using the Verilog HDL programming language based on the produced flow chart of the proposed car washing system. Depending on the amount of money invested and the washing technique, the control in place offers a choice of five regimes.

REFERENCES

[1] Marin Zhilevski and Vladimir Hristov, "Design of an Automated Car Washing System with Verilog HDL", Conference: 2021 3rd International Congress on Human-Computer Interaction, Optimization and Robotic Application(HORA),2021

[2] K. Vidyasagar, R. Prasad and P. Nagasekhar, "RFID-GSM Autonomous Car Washing System", International Journal of Computer Applications, Vol. 121, No.2, pp. 30-33, 2015.

[3] Y. Yu, L. Kurnianggoro and K.-H. Jo, "Design of intelligent car washing system", Conference: 2015 54th Annual Conference of the Society of Instrument and Control Engineers of Japan (SICE), 2015.

[4] G. Subramanian, K. Tharani, Raja, K. Gowtham Babu and T. Devashena, "Simulation of Automatic Car Washing Using PLC", - International Journal for Scientific Research & Development, Vol. 3, No. 01, pp. 438-439, 2015.

[5] M. Thwe, H. Min and N. New, "Programmable Logic Controller based Automatic Car Washing System", Iconic Research and Engineering Journals, Vol. 2, No.11, pp. 1-7, 2019.

[6] Z. Lalluwadia, N. Bhatia and J. Rana, "Automatic car washing system using PLC", International Journal of Innovative Research in Technology, Vol. 3, No.9, pp. 40-43, 2017.

[7] T. Pinjari, M. Hadpad, D. Sukale, D. Mulgoankar and P. Aswar, "Automatic Car Washing System using Microcontroller", International Research Journal of Engineering and Technology, Vol. 7, No.6, pp. 2711-2714, 2020.

[8] R. Singh, S. Nigam, S. Aggrawal, M. Neelgar, S. Kaura and Kailash Sharma, "Design and implementation of automatic car washing system using PLC", International Research Journal of Engineering and Technology, Vol. 5, No.5, pp. 4183-4185, 2018.

[9] V. Taraate, Digital Logic Design using Verilog – Coding and RTL Synthesis, Springer India, 2016.

[10] P. Chu, FPGA Prototyping by Verilog Examples, John Wiley & Sons, Inc, 2008.

[11] S. Brown and Z. Vranesic, Fundamentals of Digital Logic with VHDL Design, The McGraw-Hill Companies, 2009.

[12] B. Zeidman, Designing with FPGAs and CPLDs, 2002.

[13] B. Patil, R. Henry and A. Patwardhan, "Training methodology: Complex programmable logic device based system design & implementation", 2nd International Conference on Education and New Learning Technologies, pp. 1995-1998, 2010.