Design and Simulation of Automatic Cash Changing Vending Machine using HDL

Shashank Singh[1], Gaurvi Khatri[2], Nitika[3*]

[1,2] Department of Robotics and Artificial Intelligence, Manav Rachna University, Faridabad, Haryana, India
[3] Department of Electronics and Communication Engineering, Manav Rachna University, Faridabad, Haryana, India
nitika@mru.edu.in

Abstract. The research paper demonstrates the simulation and design of a Cash changing machine using VHDL (Speed Integrated Circuit Hardware Description Language), which goals, the process of dispensing change in vending machines and based on transaction environments. The basic objective of the machine is to allow and accept a high-denomination input from the users, like as a Rs500 currency note, and return an equal amount of currency using smaller denominations based on predefined logic and preprogrammed code. The logic of the code is executed with the help of VHDL and tested via simulation tools such as GHDL 3.0[1] and GTK Wave [2] to verify its functionality. It also consists of a Finite State Machine (FSM) [3] that recognizes the input amount handled by the user and calculates the logical combination of denominations (e.g., 100, 50, 20, 10) to return an equal and accurate change. The layout of the system is created to be acceptable and scalable for multiple inputs and can be enlarged to include denominations or handle sufficient changes. The paper highlights the correct use of hardware language to develop solutions to real-world problems in real-time financial systems to represent the potential of FPGA implementation. This project helps to contribute to the field of digital design to deliver configurable modules integrated with an embedded system for a transaction environment.

Keywords: Transaction environment, Currency, FSM, GHDL 3.0, FPGA implementation.

1 Introduction

Millions of people worldwide suffer or waste their time when the shopkeeper at the cash counter wants a smaller currency note for paying the bill. In modern days, the need for efficient cash is also ever-growing. The cash changing vending machine plays a crucial role at ticket counters, small retail stores, and toll booths in facilitating quick and accurate currency transactions. These machines are created to accept a fixed amount and denominate the equal value using optimal combinations of smaller

P. Johri et al. (eds.), *Proceedings of the International Conference on Sustainable Computing and Artificial Intelligence (ICSCAI 2025)*, Advances in Engineering Research 298,
https://doi.org/10.2991/978-94-6239-674-6_19

ones. All the processes are automated to reduce manual errors and response time to improve user convenience.
This paper demonstrates the design and simulation of a cash changing vending machine using VHDL (VHSIC Hardware Description Language), and GHDL 3.0 for simulation, which is separately used for designing digital systems [4]. The focused vending machine allows the user to insert a fixed cash input (such as ₹500) and calculates the number of notes for each available denomination (₹100, ₹50, ₹20, and ₹10). The system ensures faster response times and better composition with microcontroller and embedded systems as compared to software solutions. "VHDL is a standardized hardware description language defined by IEEE for modeling and simulation of digital systems [5]."

The behavioral description of code is written in VHDL [6][7] and simulated using the tool GHDL 3.0 to verify its functionality. The vending machine not only represents the application or use of digital design but also shows the importance lays on groundworks for future advancement, like user input interface, and FPGA deployment, etc.

2 Problem Statement

The primary objective of the research paper is to build an automated digital system [8][9] that can allow users to insert a specific currency value (e.g., ₹500) and return a smaller currency combination of denominations. This machine should:

- Work in a real-world environment.
- Access basic denominations (₹100, ₹50, ₹20, ₹10).
- Implemented using VHDL for design and GHDL 3.0 for simulation.

3 Applications

The Cash Changing Vending Machine, created with the help of VHDL code, has a wide range of real-world solutions that require a fast, accurate, and automatic currency denomination machine is required. The vending machine has too many applications [10][11] some of the key areas are mentioned below:

3.1 Vending Machine

Sometimes, user needs to change their big currency notes into smaller ones. The modern automated vending machines that operate without any person and can provide accurate and equal change automatically when users insert their big currency notes. The vending machines are integrated with VHDL code and simulated by GHDL 3.0, ensuring accurate denomination and reducing dependency on other [12]. It also improves the satisfaction level of customers and happy with the response time of the machine.

3.2 Public Transportation Kiosks

Ticket counters at metro, bus, and train stations have been automated, which deal with currency transactions. The cash-changing vending machine helps people to get tickets by changing larger currency notes for low-cost tickets. This also helps people to avoid queues at the manual ticket counter.

3.3 Retail Stores and Supermarkets

Small shops or retail stores always use, or on demand for use of smaller currency at the checkout counter because they always feel a shortage of notes. So, the cash changing vending machine [13][14] is installed for comfort, to save valuable time, hence used for speedup transactions.

3.4 Automated Toll Booths

During travelling, the toll plazas sometimes require cash payment is still widespread; the vending machine can assist the driver or user in receiving exact change for the toll amount. It helps to reduce traffic blockage and enhances toll collection

3.5 Banking Kisko & ATM's

Bank branches and ATMs can offer systems to permit customers to break large currency denominations into smaller ones. The offer is especially beneficial for people residing in rural or semi-urban areas where small transactions are always in demand.

3.6 Events & Exhibitions

In the fairs, exhibitions, or festivals where a large number of people visit, we temporarily place the vending machine [15], which can help visitors to denomination larger currency notes into smaller ones by ensuring continuous use of currency

4 Methodology

This project aims to create an automated cash changing vending machine that reduces user problems like queue of bank or ticket counter at stations, enhances their feedback, and also saves their valuable time. The system is created using VHDL code and simulation by GHDL 3.0 for validation of the system. The methodology is divided into three different parts:

- Design and Implementation in VHDL
- Simulation and Waveform analysis using GHDL
- Hardware Result Validation.

4.1 VHDL Implementation

The implementation of digital logic for the cash changing vending machine was done using VHDL with the help of vending machine techonology [16], best suited for register transfer level circuits. The system is constructed of:

- Input: The cash inserted by the user followed an integer value (e.g., ₹500).
- Processing Unit: Using VHDL digital logic, the process accesses how many currency denominations (₹100, ₹50, ₹20, ₹10) are required to return the equivalent amount using the first possible largest denomination.
- Output: Four signals, each showing the count of one denomination.

According to the logic, preferences for higher denominations are to minimize the number of notes. When implemented on an FPGA, a synchronous reset and clock-driven process enable its predictable behavior.

4.2 Simulation & Results

The simulation was done on the EDA playground environment [17], GHDL 3.0. The module of testbench (tb_cash_changer) was made to apply different inputs and monitor outputs. The testbench performs:

- The design initializes using a reset pulse.
- Gives test inputs like ₹500, ₹270, and ₹90.
- The system waits for computation and then stores outputs.

Using GTK waves [2] were conceived to create the simulation waveforms. All outputs matched inserted values: for example:

- ₹500 outcome in 5 x ₹100 notes,
- ₹260 outcome in 2 x ₹100, 1 x ₹50, and 1 x ₹10 notes.
- ₹90 outcome in 1 x ₹50, 2 x ₹20 notes.

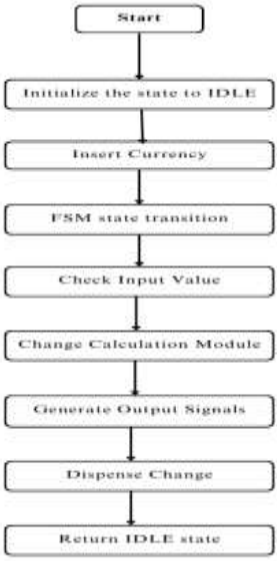

Fig. 1. Flowchart of Process

In Fig. 1, the flowchart shows every step of the cash changing vending machine

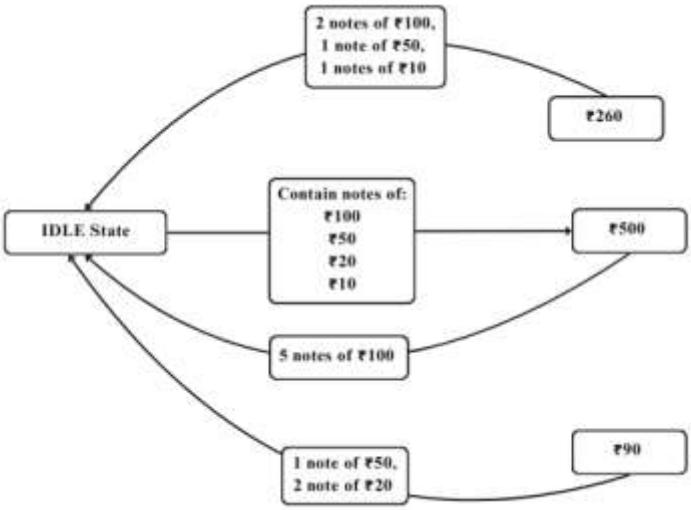

Fig. 2. Currency conversion into smaller ones

5 Validation

To ensure the correctness, the system was verified against manual calculations. The Outputs from simulations were collated to actual notes foundering and found to be accurate. The design is integrated and can be implemented on FPGA boards for real-time operation.

6 Future Work

The future iteration of the cash-changing vending machine can be improved by allowing and managing multiple input denominations for a particular time and dynamic change allocation based on availability. The machine integrates with real-time sensors to allow physical currency notes to be made. The machine is deployment-ready for ATMs. Additionally, the system allows for handling digital transactions, like as QR-based payments can integrate its applicability and customizability [18][19]. The machine also allows for to detection of fraud cases with the help of a machine learning algorithm and also performs pattern recognition to enhance the security of the system [20][21]. Integrate with an FPGA board that verifies its performance in the real world and use it for commercial applications.

7 Conclusion

The implementation of a Cash Changing vending Machine using VHDL code and simulation GHDL 3.0 has illustrated the efficiency of hardware description languages in modeling and simulating financial automation machines. To design the FSM efficiently using VHDL to accept fixed input and dispense equivalent denomination as change, the cash changing vending machine effectively recreates a fundamental real-time transaction as a form of digital process. Simulation using GHDL and GTK waves verified the accurate operation under different scenarios, also validating the reliability and accuracy of the system.
Adding more denominations, upholding multiple inputs, or modifying the sensor allows the system to be designed for future enhancement. FPGA integration with the system makes it more fitting for deployment, and cash handling is essential at the point of automated service. Also, explain how VHDL can solve real-world problems in the field of embedded systems and automation.

References

1. GHDL: GHDL is an open-source VHDL simulator.
2. GTKWave: An Open-Source Waveform Viewer.
3. Monga, A. and Singh, B., 2012. Finite state machine based vending machine controller with auto-billing features. arXiv preprint arXiv:1205.3642.

4. Mano, M. M., & Ciletti, M. D. (2017). Digital Design with an Introduction to the Verilog HDL, VHDL, and System Verilog.
5. IEEE Standard VHDL Language Reference Manual.
6. Bhasker, J. (1999). A VHDL Primer. Prentice Hall PTR.
7. Pedroni, V. A. (2004). Circuit Design with VHDL. MIT Press.
8. Wakerly, J. F. (2006). Digital Design: Principles and Practices (4th ed.).
9. Roth, C. H., & John, L. (2017). Digital Systems Design Using VHDL.
10. Thamizhamuthu, R., Raja, R.K. and Mishra, S., 2025, February. A Controlled Gesture Smart Vending Machine Using AI Techniques. In 2025 International Conference on Innovative Trends in Information Technology (ICITIIT) (pp. 1-7). IEEE.
11. Okafor, P.C., James, G.G. and Ituma, C., 2024. Design of an Intelligent Radio Frequency Identification (RFID) Based Cashless Vending Machine for Sales of Drinks. British Journal of Computer, Networking and Information Technology, 7(3), pp.36-57.
12. Kumar, R., & Rajesh, M. (2020). "Design and Simulation of Currency Sorting Machine Using VHDL." International Journal of Engineering Research & Technology.
13. Huppatz, D.J., 2021. Robot salesmen: automated food retailing in the United States, 1925–39. History of Retailing and Consumption, 7(3), pp.261-276.
14. Chungath, I.I., Varghese, N., Kumar, D. and TS, D., 2024, December. Solar Powered Raspberry Pi Based Snack Vending Machine Using QR Code. In 2024 International Conference on Advancement in Renewable Energy and Intelligent Systems (AREIS) (pp. 1-6). IEEE.
15. Sircar, A., Ghosh, B., Tanvin, J.U., Siddiqui, M.A., Mim, S.T. and Islam, M.N., 2025, February. Exploring the Usability of Vending Machines through Multi-Method Evaluation Techniques. In 2025 International Conference on Electrical, Computer and Communication Engineering (ECCE) (pp. 1-6). IEEE.
16. Ratnasri, N. and Sharmilan, T., 2021. Vending machine technologies: A review article. International Journal of Sciences: Basic and Applied Research (IJSBAR), 58(2), pp.160-166.
17. Doulos Ltd., “EDA Playground: Online VHDL/Verilog Simulator,”
18. Solano, A., Duro, N., Dormido, R. and González, P., 2017. Smart vending machines in the era of internet of things. Future Generation Computer Systems, 76, pp.215-220.
19. Chung, S.K., Yew, H.T. and Kiring, A.M.C.J., 2024. IoT-Based Vending Machine. In Internet of Things and Artificial Intelligence for Smart Environments (pp. 57-65). Singapore: Springer Nature Singapore.
20. Henriques, S., Lewis, S. and Kotian, G., 2022. An IoT-based vending machine using blockchain for enhanced security. Journal of IoT in Social, Mobile, Analytics, and Cloud, 4(3), pp.153-164.
21. Ramzan, A., Rehman, S. and Perwaiz, A., 2017, April. RFID technology: Beyond cash-based methods in vending machine. In 2017 2nd International Conference on Control and Robotics Engineering (ICCRE) (pp. 189-193). IEEE.